A DISCUSSION PAPER

THE TECHNOLOGY CHALLENGE: ONTARIO FACES THE FUTURE

Innovation and Technology Division
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Competitiveness, productivity and new product and process development are key to the economic future of Ontario.

How effectively we are able to respond to the challenges imposed upon us by increasing world competition depends, in part, on how we respond to the technological challenges facing us. This discussion paper is intended to raise some of the issues which are vital to the Province of Ontario if it is to remain in the forefront of technological change and benefit from it.

While The Technology Challenge: Ontario Faces The Future does provide a broad agenda for action, it is neither comprehensive nor definitive. Its aim is to encourage further discussion and draw attention to the need for a combined effort on the part of business, education, labour and government.

Yours sincerely,

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EXECUTIVE SUMMARY

During fiscal 1982/1983, the Ontario government established six Technology Centres and IDEA Corporation. During the implementation of these initiatives, it has become increasingly apparent to the Technology Centres Unit of the Ministry of Industry and Trade that the pace of technological change is having a dramatic impact on methods and costs of production, use of materials, availability of information and management/labour relationships. Technology promises to be as dramatic and sweeping in its consequences as was the Industrial Revolution.

The issues arising from the pace and scope of technological change are complicated and potentially threatening to existing delivery structures and mechanisms unless properly addressed and managed. In Canada, the technology objectives of government and the private sector are largely unclear and uncoordinated. The urgency of developing an overall technology strategy for Ontario has also become apparent. As an initial step in this direction, it was considered worthwhile by the Technology Centres Unit to examine the pace of technological change, the major implications for Ontario, the role of government and actions necessary over the short term to take advantage of the opportunities identified.

CHAPTER 1 - TECHNOLOGY: A CHANGING WORLD

Chapter 1 provides an overview of developments, forecasts and applications on an international basis in six selected technologies. The technologies selected for review are microelectronics, computers, optoelectronics, biotechnology, advanced manufacturing and advanced materials. The selection criteria were based on technologies that are:

- receiving massive public and private sector support in other countries and could significantly affect Ontario's industrial and trade competitiveness;

- providing the basic underpinnings for developments in other technologies and for applications:

- likely to undergo a rapid rate of change within the next decade.

Today's reality is that an understanding of the impact of technology must be of vital importance to all business and government decision makers if opportunities are to be maximized and Ontario's competitiveness in world markets maintained. This overall observation is based on the following general conclusions drawn from an analysis of the technologies reviewed in the paper:

. Increased levels of specialization and the use of modern analytical techniques and tools are enabling dramatic advances in a variety of technologies at the same time.

. The unprecedented pace of change and range of applications are opening new opportunities for industry and trade, as well as threatening the future of some mature industries and the communities that depend on them. Fundamental adjustments will be required in many traditional industries and institutions.

. Microelectronics is the key driving technology behind nearly all modern electronic devices. The tremendously increased functions that can now be obtained at realistic costs have given rise to the information revolution and to the threshold of a new level of computing capabilities. These capabilities will be applied to almost all facets of industry, government and society.

. The decreasing costs of general purpose computers and the increase in computer power will make these tools affordable to all companies.

. Computer software is coming to be considered as the "new wealth of nations" and the area of maximum added value. Both computer hardware and software will capture increasing shares of the goods and services produced by an industrial society.

. In the telecommunications area, fibre optics is being driven by the increasing demand for data communication and voice traffic. The advances in the technology and the decrease in costs seriously threaten traditional resource value assumptions, for example that of copper.

- The diffusion of biotechnology R&D into practical applications is significantly affecting a broad range of industries through new product development and decreased costs. In view of the dramatic decline in traditional manufacturing industries, advances in biotechnology are being aggressively pursued to create replacement job opportunities and new wealth.

- Advanced manufacturing technologies are rapidly evolving from those which initially provided mainly drafting assistance to what is today an impressive list of manufacturing tools. The adoption of these technologies holds significant competitive advantages for manufacturers in terms of cost, productivity, quality, reliability, speed and inventory control.

- Radical advances in high-performance materials have led to significant breakthroughs in products and processes. These represent not only potential industrial and market opportunities, but also a significant disruption to existing industries and markets, which are increasingly being replaced by advanced materials.

- International competition in each technology is formidable and intense. This has meant that joint programs and cooperative R&D consortia among universities, government and industry are being formulated in many countries. Japan, most notably, is committed on a national scale to the development of a wide range of technologies such as the fifth generation computer and advanced ceramics. Other countries' support to meet the challenge is generally in encouraging applications, stimulating domestic production, promoting basic R&D and funding recapitalization.

The above conclusions are supported by the commentaries on each technology in the paper. The following briefly highlights the significant points from these commentaries.

A. Microelectronics

The key factors sustaining further advances in microelectronics are the following:

- Continuing progress in silicon processing has led to rapid increases in the capability of integrated circuit components.

- This increased capability is being used to create components with increased functions, reliability, versatility and processing speed that occupy less space, are lighter and are more energy efficient. Although the 64K RAM chip is the most popular today, IBM has recently developed an experimental 512K chip that has eight times the storage capacity.

- Components are dramatically decreasing in price, as the manufacturing volume increases, so that cost effective applications will continue to emerge. Manufacturing costs are predicted to continue to drop at 20 to 30 percent a year during the next few years.

- The increase in microelectronic applications is projected to double the value of worldwide silicon device shipments every five years, reaching $60 billion in 1990.

- Companies that have profited from microelectronics have sought world market volumes, highly automated manufacturing and highly skilled innovative research talent.

- The use of the microelectronic chip in new products and manufacturing processes offers opportunities to manufacturers for product innovation, improved quality and increased productivity.

Recent reports indicate that the supply of some custom chips is unable to meet the demand, given the dramatic increase in microelectronic applications. It is projected this could lead to a severe worldwide shortage of chips about 1987 and create a major concern for manufacturers.

The range of microelectronic applications is increasing at a dramatic pace in computer and office machines, telecommunications, industrial and test equipment, government and military equipment, consumer products and automobiles. For example, in 1978 the automotive sector used only $20 million worth of semiconductor devices. Such usage is expected to reach $800 million in 1983 due to the rapid adoption of microprocessors, sensors and controls for engine pollution and safety features.

Canada has a growing industry in applying microelectronic components to the information and communications industries, where world market opportunities are being successfully exploited. However, Canada has little capability in the design, manufacturing and marketing of state-of-the-art components except for Northern Telecom and Mitel. There is no Canadian manufacturer of a range of semiconductor devices for the general electronics market, which is almost totally dependent on importing chips for manufactured products.

B. Computers

The dawn of computers may be seen as one of the most significant events in the development of humankind. The massive, fast and accurate processing of data outside the human mind has enhanced our capability to deal with scientific, administrative and technical tasks of complexities previously unthinkable. Computers will increasingly become part of every human activity involving the manipulation of numbers or data.

The amazing developments in the performance of computers have been made possible by the progress in microelectronics, the associated decrease in the cost of logic and memory, and advances in software, which controls the system and defines its capabilities. As the performance-cost ratio of microelectronic devices continues to increase, functions now performed by computers will become cheaper to implement, making this facility available to increasing applications in the office, plant and home.

Software is coming to be considered as the "new wealth of nations" and the area of maximum added value. It is predicted to be the driving force behind future computer advances. Software costs increased to 50 percent of the total system cost in 1980 and are expected to reach 70 percent by 1990. The software industry in Canada is predicted to grow an average 28 percent a year to the end of 1990. The market is expected to reach $1 billion by the end of 1983 and $5.4 billion by the end of 1990.

In the emerging economic order, advanced industrial nations are focusing on selected proprietary technology niches, such as software, to obtain strategic exports and create employment, rather than on traditional commodity products. User friendliness, compatibility and portability, as well as the high development costs, are major software related issues facing many companies.

Advances in computers will be seen in the following areas:

- Trends are toward an annual increase in available computer power of about 40 percent and a decrease in the cost of small general purpose computers at an annual compound rate of about 25 percent.

- A recent development allows 10 trillion bits of digital data to be stored in an optical memory system. This capability will significantly reduce time for information retrieval and data storage space and increase the volume of stored information.

- Coupled with rapid advances in fibre optics and transmission media such as satellites, it is inevitable that a society completely interconnected for communications will emerge.

- The computer, with the appropriate software, can be used to undertake design simulations of a complexity that only recently would have been economically unfeasible or have occupied too much time. Such developments become an equalizer in that more businesses will have access to more sophisticated data to compete with each other.

- By the end of the 1980s, the impact of artificial intelligence (AI) will begin to appear in almost all computer-related devices. A goal of AI is the recognition of human speech,thereby removing the necessity of formal programming languages and making computers accessible to all levels of society. For example, both stationary and mobile robots, augmented by voice input/output, vision and reasoning power, will be available for manufacturing as well as for home care of the aged or infirm.

Both computer hardware and software will capture increasing shares of the goods and services produced by an industrial society. There are niche opportunities for Canadian companies to develop specialized application software running on foreign hardware and also for specialized hardware. The joint development of large software systems, hardware architecture and microelectronics implementation will be necessary and will provide a sizable management challenge. For any country to maintain a competitive industrial base, it will need to formulate and execute a viable strategy in this technology.

C. Optoelectronics

Fibre optics technology involves transforming information into beams of light and transmitting them along glass fibre cable. Fibre optics systems provide greatly increased capacity and expansion at much lower costs than conventional copper cable technology for data communication and voice traffic. For example, whereas copper cable requires a repeater device each six to eight kilometres to boost signals over long distances, fibre optics systems only require one device each 30 kilometres. Major applications include cable television, remote terminals-to-host computer linkups, process controls, power company line and highway monitoring systems, automotive systems, word processing and local area networks.

Canadian fibre optic producers are in the first rank worldwide. Most notable is Northern Telecom.

A laser is a device that uses an energy source and a lasting medium to amplify light waves and generate intense and highly concentrated beam of light. Laser technology is being used in industrial, scientific and medical applications. For example, in cataract surgery, light severs eye membranes while passing through the lens of the eye without inflicting damage. This technique has reduced a four-hour surgical operation to an out-patient procedure lasting minutes.

A small number of Ontario companies are active in the laser area. Lumonics is the third largest commercial manufacturer of lasers in the world.

D. Biotechnology

New biological techniques have emerged at a critical time in the economies of the developed countries as they are witnessing a dramatic decline in traditional manufacturing industries. Consequently,

biotechnology R&D is being actively pursued to create replacement job opportunities and new wealth. In Japan, biotechnology has been rated as the number one growth potential industry by 662 Japanese companies.

The diffusion into practical applications will inevitably bring significant changes to a wide range of industrial sectors, including agriculture, food products, chemical products, mining, health care and energy and waste treatment.

For example, in the food industry, applications have advantages in decreasing costs, assuring constant supplies of raw materials, improving shelf life and enhancing commodity products. In mining, it is predicted that applications could open up previously unavailable reserves as well as reduce the cost of recovery from existing sources. It is expected that health care, particularly in the pharmaceutical industry, will be the most affected in the next decade. Applications include genetic engineering of micro-organisms to produce desirable medical products.

The case for government involvement in this field is strong. Major upfront investment is required for R&D, but profitable returns may take a minimum of five to ten years.

In Canada, there appears to be a practically non-existent biotechnological industrial base, according to the Ministry of State for Science and Technology. A major initiative is the government of Ontario's investment, along with CDC and Labatts, in Allelix Inc.

E. Advanced Manufacturing Technologies

Manufacturing represents one of the largest single application areas for many new computer-based technologies.

Advanced manufacturing technologies include: computer-aided design and manufacturing (CAD/CAM), group technology (GT), computer-aided

engineering (CAE), computer-aided process planning (CAPP), computer-integrated manufacturing (CIM), robotics and computer system integration.

Successful implementation of advanced manufacturing technologies for individual production tasks demands, above all, the integration of particular user requirements with the capability of the technology. These technologies can be applied beyond the traditional areas for design and automation. They have an effect on all manufacturing areas, from the shop floor to the executive suite, where significant amounts of working capital are now invested. For example, CAE computer simulation of the behavior of a part, when subjected to force, temperature and age, can be used to significantly improve reliability and reduce the need for costly prototypes and real life testing. The interactive CAD/CAM production information system is the key to improving delivery, reducing production costs and cutting inventories.

In Canada, computer-integrated manufacturing is still an emerging concept. A number of Ontario firms are actively pursuing different sub-segments of this area. The impact of these technologies on the manufacturing sector is just beginning.

F. Advanced Materials

The development of high-performance materials is critical in almost all technological advances. Industries as different as computers and automobiles invest heavily in materials research.

The six main categories of advanced materials reviewed are: steels; non-ferrous metals; superalloys; special-duty materials; non-metallics, including plastics, ceramics and composites; and semiconductors.

The application of advanced materials across a wide range of industries is having a significant impact on products and processes. For

example, market projections indicate a tremendous increase in galvanized steel framing for construction by 1990 based on an anticipated 20 percent reduction in the cost of materials and labour compared with wood. It is confidently predicted by experts that ceramics will be used to produce a more efficient diesel engine requiring no coolant or lubricant, and improved artificial bone joints for humans. The worldwide automotive market for advanced ceramics is projected to be tens of billions of dollars.

Advances in materials technology not only represent potential industrial and market opportunities, but could also result in significant disruption to existing industries and markets. Thus, the economic impact of new materials on the copper industry could be devastating.

CHAPTER 2 - TECHNOLOGY: THE ONTARIO ECONOMY

This chapter considers the producers and users of advanced technology in the context of recent Ontario trade deficits and lagging productivity growth. While the technological revolution is hitting at a time when the Ontario economy is particularly vulnerable, it brings along with it a powerful potential for competitive renewal. Flexible automation, especially in mature manufacturing industries, can sharpen our competitive weapons, although other countries have staked out a lead in harvesting its potential. It is also vital, in strategic terms, that Ontario anchor production positions in key technologies.

The past decade has dealt several harsh economic blows to the Canadian and Ontario economies, which have resulted in a steady erosion of industrial competitiveness. Evidence for this erosion can be seen in a deepening trade deficit in manufactured end products that is most pronounced in medium and high-technology commodities.

In the past 10 years, productivity growth in Canada has stagnated both in relation to our past performance and in relation to the performance of our global competitors. Of the 11 leading industrial countries, Canada ranked last in manufacturing productivity growth during the 1973-81 period.

A. The Producers of High Technology

The world economy of the late 1980s and beyond will be powerfully shaped by the international distribution of technology production. It is essential, in strategic terms, that Ontario have some representation in this area.

High-technology producers display higher than average growth performance and have come to play a more crucial role in defining our trade position. Through their impact on industrial productivity, they promise to boost Ontario's competitiveness in world markets.

Ontario producers have already established some leading foothold positions in new technologies such as lasers, fibre optics and computer software development. It should be a matter of highest priority that Ontario determine where its prospective footholds are and what measures should be taken to ensure that opportunities are realized.

B. Using High Technology: A Key to Competitive Renewal

Some of the most intractable problems of competitive adjustment in Ontario have occurred in our mature manufacturing industries. Many of these industries are in danger of becoming vulnerable to low-cost import competition and the drift to offshore production.

A new factor in the competitive equation for Ontario is that technology can provide entirely novel opportunities for the regeneration of mature industries. Many companies in mature industries can rejuvenate

themselves and compete if they invest in various types of flexible automation systems and harness their competitive potential by learning to manage them well.

The economics of flexible automation are becoming increasingly attractive: declining equipment costs relative to labour, along with substantially higher equipment productivity, are leading to shorter payback periods.

C. The Use of Flexible Automation: Ontario and Its Global Competitors

Some of Ontario's global competitors have responded to these shifting economics through substantial investment in flexible automation. Examples of their remarkable productivity results are presented. Chapter 2 also discusses the competitive impact of this technology on Ontario industries such as automobiles, medical devices, clothing and footwear. In one of the Ontario companies discussed, a new flexible machining system installed in 1983 has cut required machining time by 76 percent, labour requirements by 89 percent (although no one is being laid off) and required equipment downtime to virtually zero. All of the output from this flexible machining system is being exported.

Although the productivity results of flexible automation are beginning to emerge here, evidence is presented that indicates that Ontario lags behind its international competitors in applying this technology.

CHAPTER 3 - TECHNOLOGY: THE MANAGEMENT CHALLENGE

Some of the most serious obstacles to successfully implementing technology are attitudinal, not technical. One of the central themes of this chapter is that new approaches are needed in order to "work

smarter." Management and labour as adversaries has become an outmoded way of doing business as the requirements of technology place a premium on team problem-solving skills and the skillful integration of new processes into manufacturing operations.

One of Ontario's most vital competitive resources is the pool of managers charged with the introduction and oversight of technology. With the technical capacity of equipment pushing into new frontiers, companies hoping to benefit from it face a daunting set of challenges in fully harnessing its potential.

These challenges arise throughout organizations, from the shop floor to the executive suite. Although a body of experience is beginning to emerge among a few companies, this learning situation is unprecedented, and many will find themselves attempting to navigate largely uncharted territory.

It is becoming clear that new technology's promise for increased productivity needs to be harnessed by managerial behavior that is counter to many traditional approaches. Technology-driven production capabilities need to be managed differently and require some basic departures from traditional management responses. In particular, emerging experience indicates that the traditional emphasis on workers' productive job execution needs to be extended to developing workers' productive potential. Increasingly, front-line workers are supervising production operations and freeing managers for planning production.

The experience of our Japanese competitors may be instructive here. In operational terms, inventory is treated there as a debit rather than an asset - a reservoir where higher costs and production problems can hide. On the other hand, labour in Japan is treated as an asset, with dynamic capabilities that can be developed, nurtured and shaped into a formidable competitive weapon.

The competitive enhancement gained by maximizing technology's capabilities in a plant or office, and the need to respond efficiently in order to harness its potential, are now helping to shape new managers, new workers and their meeting grounds - new organizations. Chapter 3 discusses several of these emerging organizational innovations and how they are being put to work in Ontario: quality control circles, venture teams, small group activities, just-in-time inventory control, statistical process control, improved productivity sharing, gatekeeping and group technology.

If Ontario industry cannot compete as effectively as in the past for assembly dollars and jobs, then it must compete in the high ground of value-added investment areas where sophisticated workers and management jointly offer attractive returns. It is imperative not to lag in, or abandon, this management and organizational thrust, nor to deny the training and educational support that it requires.

Offsetting the low labour costs and other advantages of many offshore producers demands that Ontario industry place a premium on organizational efficiency as well as on equipment productivity.

CHAPTER 4 - TECHNOLOGY: FEDERAL AND OTHER PROVINCIAL GOVERNMENT ACTIVITIES

Chapter 4 and appendices A and B briefly summarize the major policy and program initiatives to support technology at the federal and other provincial levels in Canada. The general trends across these initiatives include the encouragement of technology transfer and modernization of industry, productivity improvement and product development, support to high-technology industries through industrial assistance and capital grants, and cooperative activities among the various levels of government.

In May, 1983, the federal government announced a technology policy for Canada to act with, and through, economic, fiscal and industrial policies. Many of the initiatives are supportive of Ontario's programs. However, the inevitable pressure on the federal government to disperse funds in accordance with economic needs raises questions as to the appropriateness of the regional focus of some of its technology initiatives. The generally diffuse focus of the federal technology policy may not fully complement or enhance provincial priorities and industrial strengths to their fullest.

As in the case of the federal programs, there is a need for Ontario to liaise with the wide range of provincial research facilities, technology transfer centres and other technology initiatives to maximize resources.

CHAPTER 5 - TECHNOLOGY: ONTARIO'S ACTIVITIES

In previous chapters, an overview has been given of the rapidly changing technological, economic and working environment within which individuals, businesses and governments will operate during the next decade. In recognition of some of these factors that make up this new environment. the government of Ontario in 1982/83 established six Technology Centres and IDEA Corporation. Ontario has taken a lead with these major initiatives to assist industry in taking advantage of technological opportunities and thereby remaining competitive. In an effort to maximize existing resources, these initiatives have been built upon the existing infrastructure and designed as a major component to support industry.

In this context, the Technology Centres are not basic R&D facilities like many centres in other provinces. Rather, they facilitate the transfer of technology through their applications orientation.

Likewise, the essential purpose of IDEA Corporation is to advance the process of commercializing technology by levering private sector funds through its venture capital investments.

In this chapter, a detailed review of the background, mandate, programs and activities to date of the Technology Centres and IDEA Corporation is provided. They provide an opportunity for businesses to obtain expert advice. technical consultation, information, training and venture capital in order to apply technology to their products and processes.

In addition, a brief listing of various technological activities by selected ministries is provided. This indicates both the diverse nature and breadth of activities sponsored by the Ontario government and the need to ensure an appropriate level of direction, priority setting and coordination between these activities.

CHAPTER 6 - TECHNOLOGY: IMPLICATIONS AND STRATEGIC CONSIDERATIONS FOR ONTARIO

The purpose of this chapter is to relate implications of immediate strategic relevance to Ontario industry at least in the short term. The detailed objectives and action plans arising from these implications are discussed in Chapter 6 and summarized in Chapter 8. For purposes of this executive summary, the action plans will be listed under broad categories on page xxviii.

1. Technology Implications

A. Microelectronics

Ontario currently has many high-profile microelectronic companies that have successfully focused on world market niche opportunities. Further, with the rapid increase in microelectronic

applications, there is enormous growth potential for the electronics industry in Ontario.

However, given the rapid pace of worldwide technical developments, unless electronics companies can keep up to date with developments and continue to foster niche areas of expertise, they will be unable to maintain a competitive position. Unless manufacturers apply microelectronics to their products, they will no longer be competitive. Since the chip is the heart of microelectronic advances, the issue of chip production is discussed in the context of supporting the development of a healthy electronics industry and protecting the vulnerability of manufacturers to potential shortages in chip supplies. Both sectors will increasingly depend on state-of-the-art chips as a basic commodity for survival.

B. Computers

It is apparent that a source of future wealth and employment is to develop niches in customized software to support the service sector, the short production orientation of many secondary manufacturers in Ontario, and the information industry. One of the major implications of not developing a competitive software industry and marketing its products is that Ontario will become increasingly dependent on importing software, rather than creating export potential.

There is general agreement that software advances will be a driving force in the computer industry during the next decade compared to the hardware side. Whereas several large companies have dominated the hardware market, the software industry remains more open for new entrants to establish a competitive foothold. There may be significant opportunities for Ontario to take a leadership role in selected software niches, based on the wealth of technical expertise in industry and universities.

C. Optoelectronics

It is essential in strategic terms that Ontario nurture its existing world-class production niches in optoelectronics in view of the rapid pace of technological change and the substantial R&D efforts of other leading producers.

The potentially adverse effects of rapid optoelectronics developments on Ontario suppliers of some mature technologies and products raise major concerns. For example, the severe disadvantages of copper wire compared to fibre optics in communications systems raise serious implications for the future viability of copper producers in Northern Ontario and the communities dependent upon them. There is an urgent need for in-depth industrial/technological information to be disseminated within government and the private sector as a basis for assessing our strategic position in optoelectronics, defining niches and identifying what supportive action is required.

D. Biotechnology

The need for the careful selection of production niches in biotechnology is underscored by certain key factors now prevalent in the industry: the technology in its current stage of development is research intensive; massive investments in R&D are required; lead times to widespread product commercialization are frequently uncertain and long; the potential areas for application cover a wide variety of industries; and the international competition is formidable.

The major strategic considerations for Ontario are the need to create and maintain an R&D infrastructure in biotechnology, and to focus such efforts within selected areas that hold realistic promise of international competitive success for Ontario producers. The need for gatekeeping, given the above factors, is of critical importance to Ontario.

E. Advanced Manufacturing Technology

The opportunities represented by advanced manufacturing technology for Ontario's industries to regain global competitiveness and the management challenges posed in effectively capturing their competitive potential are major areas for strategic consideration. These are discussed in the economic and management implications sections of Chapter 6.

F. Advanced Materials

The opportunities in advanced materials hold substantial potential for growth and for having an adverse impact on Ontario producers of traditional industrial materials. Currently it is not possible to fully detail these opportunities and potential dangers. Therefore, it should be a matter of great concern that Ontario knows so little about the relations between advanced materials opportunities and its existing materials base. As in the case of optoelectronics, a lack of awareness can lead to missed opportunities as well as to vulnerability to disruptive changes that may adversely affect Ontario's traditional materials industries. Once again, the need for an information gatekeeping function is critical.

G. Technology Transfer: Brokerage and Gatekeeping

As mentioned above, there is a real need for Ontario industry to have access to state-of-the-art information on a broad range of technologies. Without such intelligence of how our economic base may be threatened or what new skills will be demanded from labour and management, manufacturers will not be able to assess their relative positions nor will R&D necessarily be promoted in the appropriate directions.

Given the existing constraints on the Technology Centres to perform a broad technology gatekeeping function, the need for an overall,

coordinated gatekeeping function is raised. The issue is whether the dissemination of advanced intelligence on a broad scale is the responsibility of the private sector. the government or both. If there is a gatekeeping role for government, the issue is how the federal and provincial governments should interrelate to provide the most effective service.

In terms of a technology brokerage function, the issue is whether IDEA Corporation in its current and early form can effectively undertake such a function, given its venture capital mandate and revenue imperatives. If not, there is a need to consider whether IDEA Corporation should be structured differently to allow it to undertake a broad brokerage function or whether a different mechanism needs to be developed.

2. Economic Implications of Technology

A. The Producers of High Technology

There is little doubt that high-technology exports should form a cornerstone of Ontario's trade strategy. The present Ontario high-technology trade deficit should be urgently and directly addressed.

For Ontario, the production and application of new technology across the industrial base of the province should be a strategic priority. However, the program design objectives, the required linkages, and the expectations of governments and the business community are at present unclear.

It appears that two areas merit particular attention: encouraging the transfer of technology in cases with export potential and seeking out new markets for technology beyond our two largest customers, the United States and Great Britain.

B. Research and Development Consortia

One consequence of small size and working capital limitations is that research and development opportunities that find an active take-up in other countries may not find a response in Ontario. A possible solution to this problem may lie in greater research and development collaboration among groups of companies with similar interests and needs.

The most prominent examples of larger-scale technology development collaboratives or joint ventures are provided by the Japanese experience. One rather striking feature of the Japanese cooperative R&D projects is the immense size of the participants. The modest size of many Canadian technology companies and their consequent need to spread research risks suggests that the idea of pooling resources may be even more appropriate here. As well, the impressive success rate of the Japanese projects strongly suggests that a sense of urgency is warranted.

The combination of these strategic considerations, the need for risk-spreading and an urgent response, suggests attention be given to devising creative ways of extending any private cooperative research base to include university resources whenever appropriate.

C. High Technology Application: Industrial Regeneration and Productivity

Introducing and effectively managing flexible automation equipment and systems can provide a powerful new set of competitive weapons for Ontario industries. Among them are higher productivity, lower cost, shorter product development times and more exacting quality control.

While flexible automation is able to confer benefits on a variety of companies within a range of industries, it holds three key strategic implications for Ontario that deserve to be highlighted: its greatest benefits can be captured by mid-volume, mid-variety manufacturing

operations: it plays to one of Ontario's key strengths of a highly educated work force: and timing is essential. It is expected that both further development and more extensive diffusion of this technology will accelerate before 1985. Our global competitors are adopting it now and have staked out a lead over Canadian users. The competitive prowess of Japanese companies, especially in low-cost, high-quality manufacturing, could be strengthened considerably if this growing "diffusion gap" is allowed to expand further and as the extent of their managerial and employee experience with flexible automation grows along with it.

D. Working Capital and the Need for Recapitalization

The need for creative approaches to financing recapitalization is underscored by the heavy debt loads and consequent narrow room for financial maneuvering for many companies emerging from the recession. Timing for these companies can often be critical as they try to position themselves to match the technical and cost levels of their international competitors. Ironically, the apparent inability of many balance sheets to accommodate the acquisition of advanced manufacturing technologies can mean that the rapid payback and substantial productivity gains characteristic of these technologies simply may not be realized. Consequently, their chances for recovery or even survival, could be impaired. This problem is accentuated when some of the companies most in need of capital restructuring are privately held.

Chapter 6 discusses some alternative approaches to the financing problem that recognize the constraints facing both Ontario manufacturers and the government. These include: interest relief assistance, equipment leasing, channelling venture capital funds and the encouragement of private technology investment pools.

3. Management Implications of Technology

Coping with the new technologies presents business management and government with some adjustment challenges of unprecedented latitude. The major implications of these fall within three broad categories: training efforts both for those displaced by technological change and for those holding jobs that now require new skills: focusing education resources and coordinating their specializations with emerging strategic needs: and ensuring that public management responsibilities are focused, up-to-date, and provide the requisite direction and support to enhance private sector efforts.

A. The Job Displacement Problem

In many cases, the resident skills of the unemployed have been rendered redundant by technological advance - machines are executing their tasks more efficiently.

Neither the future dimensions nor the sectoral or regional effects of technological unemployment are known with any degree of precision. Whatever the numbers, the potential for displacement is unsettling. The expected loss of employment as a result of technology should not, however, lead to a decrease in technology investment, but rather to a concerted effort to reduce the negative effects at all levels. Many contend that, given long-term competitive realities, the failure to introduce flexible automation may have a greater effect on job loss.

B. The Job Adaptation Problem

Upgrading our capital resources through investment and retooling and our product offerings through R&D and quality control are, in themselves, insufficient responses to our productivity problem. A successful attack on the worst productivity record in the OECD also

demands that the structure of organizations and the content of jobs be upgraded.

The contrasts with most previous retraining efforts are centred in three areas: broader target groups, ranging from the executive office to the plant floor: broader training agendas, as new technology and production management require a new set of skills and attitudes: and closer consultation among government, industry and labour.

It has become evident that decision-makers within government, universities and industry need better information about emerging technologies and consequent human resources training needs.

CHAPTER 7 - TECHNOLOGY: THE ROLE OF THE ONTARIO GOVERNMENT

It is evident that new directions and new initiatives are required if Ontario is to both meet the challenges and profit from the opportunities presented by new technology.

Chapter 7 reviews the current role of the Ontario government in establishing a positive climate for the private sector, the competitive threats facing the province, the complex interrelationships among the major players in the public and private sectors, and the issues facing the government both internally and externally. It concludes that in order to demonstrate the importance that the government attaches to supporting the private sector, there is a need to develop a coherent technology strategy, to secure a long-term commitment from both the public and private sectors, and to commit resources to actively manage that strategy.

The alternative mechanisms through which the government, in cooperation with the private sector, can best respond to the issues identified in this paper are reviewed. These include the experiences of other governments. Clear recognition was given to the fact that any process or mechanism will not be successful without the support,

contribution and commitment of the private sector. Nor will it have significant impact unless it is flexible enough in its approach to work within the existing government structure of specialized ministry programs and to recognize the pervasive nature of technology across many ministry and agency mandates. It is within this context that three actions relating to government process and structure are proposed.

The strategic role of BILD has been to consolidate and co-ordinate the government's total economic development program and focus on policy directions and investment initiatives in technology. This role should be taken to the next logical stage of building on its current investments and concentrating on identified priority areas. The government, as well, has to emphasize leadership, development and integration with the private sector. This will underscore the province's commitment to a solid, productive industrial structure, and BILD's role in establishing a positive climate for industry competitiveness. Appropriate levels of resource allocation, new technology initiatives, leverage and industry support should be highlighted as key elements in a long-term technology strategy.

There should be recognition within the Ministry of Industry and Trade of both the need for senior private sector representation on technology issues to the Cabinet and its Committees and for a focal point to address innovation and technology issues. As the primary outreach, on behalf of the government, to the business community, it is proposed that an Innovation and Technology Division be established within the Ministry of Industry and Trade to co-ordinate, and focus on, technology issues.

The government should, wherever possible, adopt the model of the Advisory Committee used in the development of the business plans for the Technology Centres when specific projects or initiatives are undertaken.

CHAPTER 8 - TECHNOLOGY: STRATEGIC OBJECTIVES AND PROPOSED ACTIONS

A series of objectives that emerge logically from the implications in the paper have been developed. Accompanying these are suggested priorities in both subject areas and organizational approach,which together provide a preliminary action plan. The action plan is general in nature. It is intended to direct attention to priority areas as a basis for the next step of undertaking the detailed, analytical research to formulate and support more specific policies and actions.

The action plan has been developed in the following broad categories:

- recapitalization:
- collaborative R&D:
- technology transfer: brokerage and gatekeeping:
- software industry;
- supply of custom chips;
- college and university co-ordination:
- training:
- government process and structure.

PURPOSE OF THE PAPER

This is not a policy paper; rather, it is a paper written to enable policy to be developed and action to be taken.

During fiscal 1982/1983, the Ontario government established six Technology Centres and IDEA Corporation. Ontario has taken a lead in Canada with these major initiatives aimed at creating an environment to assist industry to respond to the level of technological change taking place around the world. These initiatives have been built upon the existing supporting infrastructure to assist industry within Ontario.

Implementation of these initiatives has made it clear that the pace of change and the economics associated with technology are such that there is an increasingly dramatic impact on products, methods of manufacturing, costs of production, use of materials, availability of information and day-to-day management and labour relationships. It is also apparent that increased levels of specialization over previous decades and the application of modern analytical techniques and tools are enabling advances to be made in a large number of areas at the same time.

The issues arising from the pace and scope of technological change are complicated and potentially threatening to existing delivery structures and mechanisms. The complexity of the subject matter creates enormous difficulties for those attempting to understand the issues, while the structural possibilities resulting from coordination create a reluctance to deal with the issues in a coordinated manner.

It follows that effective policies and action will only result if there is sufficient awareness and understanding at the decision-making level of the scope and impact of technological change.

The purpose of this paper, therefore, is to raise the level of awareness by defining in basic terms some of the major effects of technological change, to discuss in a practical manner the implications and opportunities in the most obvious areas of interest, and to recommend some overall priority areas for further analysis and action and that government and the private sector work together in addressing the issues.

The analysis in this paper cannot be, and is not intended to be, technically detailed. In discussing the types of technological change it becomes apparent that in some areas the facts and implications are obvious, while in others a number of alternative interpretations are possible. However, the options and alternatives have to be understood, if not in terms of their technological detail, certainly in terms of their possible impact.

It is believed that, at this time, the level of awareness for further policies and actions to be decided upon does not exist. Therefore, some of the recommendations emerging from the paper concentrate on the need for a process to enable a greater level of awareness to be developed. Other recommendations relating to the various subjects tend to be general in nature. This is deliberate. It is believed that, at this stage, recommendations that are specific in terms of action, but that are the responsibility of specialist functions in terms of delivery, would inevitably be interpreted as threatening and, therefore, would probably not achieve their purpose.

If this paper succeeds in raising the level of awareness and in providing a basis on which to develop a structure and process for government and the private sector to work together, the next and immediate stage is to undertake the detailed analytical work to support appropriate policy positions and specific actions to be taken.

The scope of the paper is ambitious in that it has attempted to cover related aspects of technological development, management and economic issues rather than adopting the traditional piecemeal approach of focusing on specific areas. Issues emerge relating to funding, management, education, retraining, coordination and the inevitable question of priorities. Underpinning these issues, two major themes emerge from the paper.

First, it is believed that there is a need for basic intelligence or information gatekeeping on technology developments and applications throughout the world to be provided to decision makers in both the private and public sectors. This is critical if surprises are to be minimized, opportunities identified and priorities established.

Second, the opportunities for industrial restructuring and the pay-off offered by advanced technologies such as flexible manufacturing are enormous. These amply demonstrate the need for coordination, both across the private sector and in the different delivery mechanisms under government.

While looking at the next 10 years in terms of the impact of the technologies discussed, the paper is more concerned with the immediate future. IDEA Corporation has a mandate to consider the long-term issues facing this province. The Technology Centres have a relevant and important role to play. However, they have specific mandates and priorities and cannot be expected to address all of the implications of technological change taking place. Nor will they realize their full potential unless they are operating in an overall environment that is conducive to private sector investment in new technological processes and products. Therefore, it is apparent that unless immediate steps are taken to support existing industries and encourage the development of new industries, Ontario's ability to deal with the long-term future will be undermined.

CHAPTER 1

TECHNOLOGY: A CHANGING WORLD

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CHAPTER 1

TECHNOLOGY: A CHANGING WORLD

1. INTRODUCTION

This chapter provides a broad overview on an international basis of developments, forecasts and applications in six selected technologies. It is intended to increase awareness of technology-related issues and the rapid pace of technology changes, as these have the potential to adversely affect long-term industry and trade prospects if not properly addressed and managed.

In a recent study, "The Bottom Line," The Economic Council of Canada defined "technical change" as encompassing new processes, techniques, products and ways of organizing productive activities. In the context of this definition, it is apparent that technology is an inherent part of all business and economic activity. Today's reality is that the impact of technology must be of vital importance to all business and government decision makers. This is for the following reasons:

- The declining growth rates and margins experienced in many traditional industries have meant that unless they are rejuvenated through the adoption of technology they will no longer be competitive.
- The dramatic developments taking place in new technologies have given some industries a marked edge in international competition.
- Some venture capital markets have responded to technological advance by placing a high value on companies that have established, or are about to establish, reputations in these fields.
- There are significant cost advantages to be gained from effective technological capital investment.

. The major investments needed to adopt the new technologies require cooperation among diverse groups of organizations, be they government or business.

There are some basic means of taking advantage of technological opportunities. These include:

- concentration of research and development in new areas;
- application of technology to new areas for business opportunities:
- application of technology to traditional manufacturing processes and products;
- purchase of technology by license, merger or joint venture to exploit international markets.

Analytical tools have been suggested to identify which means should be taken to achieve the greatest advantage. An example is the product life cycle, whereby products and, by analogy, technologies are traced through the embryonic stage to the growth stage to the maturity stage. In this context, the inevitable suggestion is that a country and a business have to be dominant or at least strong in a growth technology because the potential return during the growth stage is higher than that at the mature stage.

Unfortunately for a country, this suggestion is frequently too simplistic, for very good reasons. If a business picks the wrong new technology or new product, it may ultimately lose a product line or even go out of business. In either event, the results are contained within the parameters of that business. A country cannot afford to take this level of risk and write off its mature industries, given the potential social, geographic and structural consequences of such action. The issue, therefore, for a country becomes whether:

- it can afford not to support its mature industries or technologies for reasons of employment, levels of previous investment or geographic dependence;
- it should divert scarce resources to new technologies and industries:
- it can afford the number of resources required in order to spread the risk of investment across several technologies.

This is further complicated by the fact that some of the new technologies, such as biotechnology, advanced materials and microelectronics, have the capability of radically changing products and processes. Thus, mature industries may find that their products are completely changed in content by new materials and new methods of operation and production. Massive reinvestment may be required to enable them to stay competitive.

It follows, therefore, that threats and opportunities can only be identified and action taken if there is a high level of intelligence and understanding of the activities of competitors and the implications of technologies that will have an impact within the foreseeable future. It is becoming obvious from the practices of other countries, the scope of intelligence required, and the size of the investment ultimately needed, that governments and the private sector in Canada will have to work closely together in order to remain internationally competitive.

The following section illustrates the dramatic advances being made and expected during the next 10 years in selected technologies, and the huge concentration of effort being made in other countries by governments and businesses working in tandem. It is hoped that this will demonstrate the need for a similar level of cooperation to be developed between the government of Ontario and the private sector if the right economic and social decisions are to be made for the short and long term.

The technologies selected for review in this paper do not necessarily represent a priority list for Ontario. Nor is this review expected to provide a thorough understanding of the technologies themselves or their implications. It is intended to provide an increased awareness of the pace of change, the vast application potential and, therefore, the extent to which existing structures are open to change. This in turn requires a clear recognition of the need to develop policies in economic, funding, educational and societal terms to ensure that opportunities are taken advantage of and managed in the most profitable way for Ontario.

2. REVIEW OF SELECTED TECHNOLOGIES

Overview

Six major technologies have been selected for review: microlectronics, computers, optoelectronics, biotechnology, advanced manufacturing and advanced materials. They generally fall within the following selection criteria:

- technologies that are receiving massive public and private sector support in other countries and could have a significant impact on Ontario's industrial and trade competitiveness:
- technologies that provide the basic underpinnings for developments at higher levels or for applications: for example, advances in semiconductors and optoelectronic devices have an impact on computers and communications technologies, which in turn affect computer-integrated manufacturing and office automation:
- technologies that are likely to undergo a rapid rate of change within the next decade.

The following section reviews technical developments, applications and potential opportunities, and public and private support by other countries in the six selected technologies.

Three factors are contributing to what will be a virtual explosion of new technologies in the late 1980s and 1990s:

. The seeds of scientific research planted after World War II are now bearing fruit.

. Global competition and worldwide demand for new products, as well as increasing constraints on the supply of energy and materials, have stimulated major industry efforts to capitalize on new scientific ideas.

. Venture capital to support and stimulate embryonic high-technology companies is becoming increasingly available.

The advances being made in each technology are occurring at such a rapid pace that it is virtually impossible to capture state-of-the-art developments on an international level. Therefore, this section provides a snap shot at an extremely fast moving target.

There are different levels of detail provided for each of the technologies depending on whether they are considered a functional underpinning for further developments and applications or an emerging technology. A broad overview of the extent to which microelectronics and computers will affect products and processes is presented. Greater detail is provided on advanced manufacturing and optoelectronics as niche areas of opportunity and on biotechnology and advanced materials as emerging technologies with great potential for application.

It will also be useful to bear in mind the distinction between technologies in which Ontario's primary interest is to create or maintain a world-class production base and technologies in which Ontario's primary interest is to encourage their further use in our industries. This distinction between high-technology "makers" and "users" is followed throughout this paper. It should become clear in this and subsequent chapters that each group - users and makers - has its own character, implications, strategic considerations and proposed actions.

The first two technologies discussed, microelectronics and computers, have enormous competitive potential for individual companies, entire industries and economies. Advanced manufacturing is included because the application of computer-based technologies to manufacturing and the payoff from automated systems and processes are becoming increasingly significant and realizable. In view of the major advances occurring in advanced materials in other countries, particularly Japan and the United States, and the potential for application throughout industry, this technology is included. Both optoelectronics and biotechnology are

reviewed because of the potential for production niches in Ontario, as distinct from the other four technologies, where the emphasis may need to be more on acquiring and applying available technology throughout our industries.

It should be recognized that while an attempt is made to describe technological developments and their significance for the non-technologist, this is extremely difficult without using technical terms in some cases. This chapter generally explains the major developments, trends and opportunities during the next decade by defining these in familiar application terms. It is expected that this summary will provide a general understanding and demonstrate that the implications and opportunities to be discussed later are based on realistic technical presumptions. As well, a backup document containing further technical detail on which this summary is based is available to anyone interested.

A. Microelectronics

a) Developments and Forecasts:

Microelectronics is the key driving technology behind nearly all modern electronic devices. The term microelectronics is practically synonymous with the silicon integrated circuit (IC) or semiconductor technology. Other microelectronics technologies, such as hybrid thin and thick film circuits, are important for specialized applications, but are insignificant compared to the importance and size of silicon technology.

The semiconductor industry is divided into three segments - wafer processing, assembling and testing, of which wafer processing is the largest.

Integrated circuits are manufactured in batch production on silicon disks or wafers by photolithographic and physical and chemical processing. Wafers contain an array of rectangular "chips" into which the

wafer is sliced after processing and testing. The chips are mounted and sealed in IC packages, usually for assembly on printed circuit boards. Chips are roughly classified by the number of individual transistors used to perform the given function. Continued progress in materials and processing techniques has moved chip complexities from low to medium to large and very large scale integration (VLSI).

It is interesting to note that the design of integrated circuits depends very heavily on complex computer-based design aids and analysis tools, and silicon processing equipment is also highly computer controlled.

Building blocks such as gate arrays (groupings of transistors) and cell libraries (modules of integrated circuits) permit systems analysts to design directly onto silicon. With such tools, it is possible to greatly reduce the design cycle of extremely complex chips. The most advanced chips today contain around a half-million transistors. A density of four million transistors per chip is projected within less than 10 years. Earlier projections along these lines have consistently materialized, and the drastic reduction in cost per function has brought microelectronics into everyday life. The major impact, however, is in the use of commercial and scientific computers, communications, automation and rapidly growing automotive applications.

The two major functions required to perform most of these tasks are data storage and data processing. Both functions have been continuously decreasing in cost, thereby allowing the handling of increasingly complex tasks. At the same time, the realization has become widespread that even rudimentary humanlike capabilities such as voice and pattern recognition or "user-friendly" person-machine interactions are highly complex and require a large amount of processing power and data storage.

The tremendously increased functions that can be obtained at realistic costs have given rise to the information revolution and to the threshold of a new level of computing capabilities loosely collected under the term artificial intelligence (AI). Such new capabilities will be applied to almost any facet of industry, government and society. The microelectronics technology that started with the invention of the transistor in 1947 is the basis for it all.

Looking ahead. a continued increase in both the number of bits per memory chip and the logic circuit density is expected. Manufacturing costs should continue to drop at 20 to 30 percent a year. although costs of very large scale integration of logic chips may not improve at quite the previous rate because of the complexity of design, testing and interconnections.

The near-term challenge involves complexity limits. How is a chip with 25,000 circuits designed? How is it tested in all of its possible modes? How is it repaired if it has a fault? Or how can it be designed so that it it self-repairing? Managing this complexity requires a high-speed computing facility and challenges mathematicians to invent more-efficient algorithms for design, simulation and testing. Complexity is the main barrier to very large scale integration.

Equally pressing are economic limits related to return on investment. A typical semiconductor production line that costs $1 million for the simpler devices of 1965 might cost $50 million for today's high density processes: but the modern line has much higher productivity. In 1980, the U.S. semiconductor industry invested almost $1.5 billion in plant and equipment. representing 17 percent of sales. This is about twice the average investment rate of all U.S. industry. The semiconductor industry is growing dramatically in response to the surge in consumer spending for products that contain semiconductors. Design costs have also

increased. Some microprocessor chips have cost vendors $20 million to design and develop.

Obviously, in the world of very large scale integrated microcircuits much effort is being placed on manufacturing in very large volume and finding ways to decrease design cost and time. To achieve these objectives, general purpose designs are being selected and programs to meet specific customer needs are being exploited.

Data storage capacity is doubling every one-and-one-half years, while the cost of random access memory is halving every two-and-one-half years. In 1960, the equivalent of one cubic metre stored a 15-page pamphlet. In 1980, the same space accommodated a 2,000-book library, and in 1990 it will accommodate the entire U.S. Library of Congress.

Because of microelectronic developments, there is an increasing shift away from optimizing the efficiency of systems and toward optimizing the efficiency of people. Microelectronics allows systems to be decentralized to a level at which they can provide support capability to individual workers.

In summary, the following major factors continue to sustain microelectronic developments:

- Continuing progress in silicon processing has led to rapid increases in the capabilities of integrated circuit components. Increasing the amount of storage on a chip increases a computer's speed and performance, while making it less expensive because fewer chips are needed in its circuit board. Although the 64K RAM (random access memory) chip is the most popular today, IBM has recently developed a 512K experimental computer memory chip that has eight times the storage capacity. Dramatic increases in chip capacity are certain to continue.

- This growing power is being used to create equipment capable of performing higher level functions, at greater speed, while occupying less space and consuming less power.
- The rapid advances in technical performance have been accompanied by dramatic reductions in price. These have led, and will continue to lead, to a much wider range of cost-effective applications for microelectronic devices.
- New areas of understanding with respect to machine intelligence, vision and speech during the coming decade will increasingly challenge current forms of human participation in work.
- The value of worldwide silicon device shipments is doubling every five years, and is expected to be $60 billion in 1990. The world market for custom chips is expected to reach $25 billion by 1990 and the market for semi-custom chips alone is expected to grow 62 percent a year through 1986.

b) Applications:

Within the context of the enormous growth in the use of silicon devices, the relative distribution of semiconductor usage from 1978 to 1983 in the United States is given in Table 1-1 (page 16).

TABLE 1-1

U.S. CONSUMPTION OF SEMICONDUCTORS BY APPLICATION SECTOR (% DISTRIBUTION)

Application Sector	1978 (%)	1983 (%)
Computer EDP and Office	56	48
Telecommunications	9	13
Industrial and Test Equipment	11	9
Government	13	13
Consumer	9	11
Automotive	2	6

The broad trends of semiconductor use in the six application sectors cited are summarized below.

i) Computer EDP and Office:

Although growing slightly more slowly than other sectors due to its large present base, total semiconductor use in this market has about doubled in the past five years, paced by the demand for memory. There will be considerable growth in small business and personal computers and increased applications of microprocessors, memory and other semiconductor devices in office machines. New devices in the future will include those for speech processing and communication.

ii) Telecommunications:

The use of semiconductors in telecommunications, especially in telephone switching. began in the mid 1970s and is accelerating. Besides being used in electronic switching, semiconductors are increasingly being used for transmission and in terminals for analog digital conversion and digital filtering that require specialized devices for these applications.

The introduction of the digital switch in telecommunications has made a fundamental change in products and their methods of manufacture.

For example, the old electromechanical switching required large quantities of fabricated metal parts. The replacement of these by microelectronics has reduced the demand for metals, for machine tools and for large numbers of production people with traditional skills.

iii) Industrial and Test Equipment:

The industrial and test sector of the electronics industry has shown a slower growth rate. However, the continuing penetration of low-cost microprocessors will ultimately result in their usage in virtually every instrument to provide control and computational intelligence. The entire computer-aided manufacturing (CAM) and robotics areas are being revolutionized by the ever increasing availability of low-cost and more-sophisticated microprocessors and other semiconductor devices.

iv) Government:

The use of semiconductors in government and military electronic equipment has more than doubled since 1978. A small portion of consumption will be met by in-house semiconductor production of major contractors that have facilities to build specialized high-technology devices.

v) Consumer:

The use of semiconductors in consumer electronics has increased rapidly in recent years. New uses in this sector include appliance control by microcomputers and solid-state switches; ROM (read only memory) cartridges for calculators, personal computers and games: personal communications: and home terminal and telephone equipment directly purchased by the consumer. The traditional applications such as television, radio and audio systems will also expand, and utilize new

types of semiconductors as well as microprocessors for control. Future use will grow further as more control of appliances becomes electronic and as the functions of personal computers expand rapidly.

vi) Automotive:

The automotive sector used only $20 million worth of devices (valued at the component or semiconductor level) in 1978. Such usage will reach approximately $800 million in 1983, due to the rapid adoption of microprocessors, sensors and controls both for engine pollution control and to provide safety features. It is predicted that if the automotive industry had enjoyed the same design and machine-tool improvements that semiconductor manufacturers have, cars would now cost $1 each and get 500 miles to the gallon.

c) Other Private and Public Sector Support:

Japan stands out as the country that is most committed, on a national scale, to the development of tools for information technology. Its Ministry of International Trade and Industry (MITI) will invest more than $500 million during the next five years toward the development of a "fifth generation" computer, based on artificial intelligence. Individual companies will invest many times more, bringing the total to an estimated $4 billion. While equivalent figures are not available for combined government and industry funding in Canada, a study prepared by R. W. Evans Research Corporation in 1981 estimated that Canada's 13 largest computer firms spent less than $25 million on research and development in Canada in 1981. Canada's computer industry is largely foreign owned.

Although Japan may still lag behind the United States in some sectors of semiconductor technology, it has developed outstanding capability in the development, manufacturing and marketing of key high-volume standard components such as large scale memories. As a result, it

now produces approximately 15 percent of the world's supply of semiconductor devices, and this market share is growing rapidly.

One example of the type of Japanese program that will cause its market share to increase is an eight-year cooperative industry-government program referred to as the High-Speed Computer Project. It was started in 1981, and is expected to include work on Josephson junctions, gallium arsenide devices and high electron mobility transistors for fast digital logic. The funding for this program alone is believed to be more than $100 million.

In the United States, there is great reliance on competition and individual initiative in the private sector for the development of semiconductor technology. However, it is interesting to note that at least two recent major research and development initiatives involve the cooperation of several companies. This illustrates a recognition of the need to pool knowledge and resources, both physical and monetary, in order to compete in this rapidly changing field.

Universities such as Stanford and M.I.T. have been key sources of semiconductor technology from the early days of the transistor, and they enjoy a very close working relationship with industry. Recently, a number of the universities have received funding to actually set up their own state-of-the-art IC fabrication facilities (chip foundries). For example, North Carolina has been given $28 million U.S. and M.I.T. has been given $16 million U.S.

The North Carolina funding will allow researchers to implement a development line in addition to a standard foundry type of line. The development line will be used for research and education in device physics and in semiconductor materials and processing, analogous to the work proposed in a recent Canadian university proposal for a National

Microelectronics Facility. Facilities of the type being proposed for Canada have been in place for at least the past four or five years at major U.S. universities. The U.S. experience can serve as a valuable crucible for the planning and execution of similar programs in Canada.

A comprehensive overview of the European scene is given in a Science Council of Canada report entitled "Government and Microelectronics - the European Experience," published in March, 1983. Recent announcements have provided evidence of greatly increased government support for microelectronics in Western Europe. For example, in the U.K., the Science and Engineering Research Council (SERC) has set up central microfabrication facilities in Edinburgh and Southampton to provide academic workers engaged in SERC supported research with access to device processing facilities. The activities of the facilities are coordinated from the Rutherford Appleton Laboratory, which is also responsible for publishing their newsletter, "Microfabrication."

On the continent, the new fabrication line of the Delft Technical University is aiming at submicron technology, while the fabrication line at the University of Dortmund has gained recognition for its work in buried nitride MOS.

In Scotland, major government incentives include financial grants from 22 percent to 40 percent of fixed capital costs of building a factory and equipping it. The microelectronics industry now employs more than the three traditional industries - shipbuilding, coal and steel - combined. Six major universities channel graduates and research to microelectronic companies.

The evidence is clear. Competition in the field of microelectronics has meant that in Japan, the United States and Europe joint programs among universities, government and industry are being formulated to meet the challenge.

d) Canada's Position in Microelectronics:

Canada, with a few outstanding exceptions, has not been a world leader in semiconductor technology, and has very little capability in the design, manufacturing and marketing of state-of-the-art components. What it does have is an excellent capability in the application of such components to the information industry, and more specifically to the communications industry. Based on these capabilities, some major worldwide markets as well as many niche opportunities have been successfully exploited. These are briefly reviewed below.

The integrated circuit industry in Canada is dominated by Northern Telecom and Mitel. Northern Telecom is one of the largest users of semiconductor devices in the world. Custom device requirements, which form a considerable and increasing fraction of the company's overall device applications, are met by their in-house semiconductor components group (SCG), which covers all aspects of silicon device production from design through to packaged devices. The SCG Corkstown Road facility in Nepean has 10,000 square metres of space and employs more than 650 staff. It contains both 75 mm and 100 mm wafer fabrication lines, which produce about 85,000 CMOS (complementary metal-oxide-semiconductor) and NMOS (N-channel metal-oxide-semiconductor) custom devices a week. SCG also has a 100 mm wafer fabrication facility and a testing laboratory in California. Northern Telecom also manufactures semiconductor lasers and LEDs (light emitting diodes) at its optical systems division for use in Northern Telecom system products.

Mitel Corporation's Semiconductor Division produces silicon monolithic integrated circuits and hybrid circuits primarily for use in the company's telecommunications products, although about 20 percent of current production is sold to outside customers. The company considers its in-house semiconductor operation as crucial to its success in

developing and selling state-of-the-art telecommunications equipment. Most of Mitel's semiconductor production capabilities are in Bromont, Quebec, where it has a 75 mm wafer fabrication line and a new 100 mm VLSI capability, based on its own modular facility design, suited for high-volume production. About 3,500 wafer starts a week are planned. A smaller VLSI capability of the same design has been proposed for Mitel's Kanata operation. Mitel has developed and ISO-CMOS (isolated CMOS) process that results in devices combining good noise immunity with high speed operation. The process has now been licensed to several device manufacturers in other countries. The total semiconductor operation within Mitel involves about 800 people.

Linear Technology, in Burlington, Ontario, has been very successful in pursuing a specialized international market in the area of low voltage linear integrated circuitry. It exports almost 95 percent of its production and is now supplying about 45 percent of the world market for hearing aid amplifiers. Current annual sales are about $5 million. About 16 percent of its gross sales go back into research and development. The company operates a 50 mm wafer fabrication line and is beginning to install a 75 mm line, which will increase production of vertical double-diffused MOS devices for application in UHF communication equipment as found in satellite communications and remote sensing.

Microtel Pacific Research Limited, the research and development subsidiary of AEL Microtel Ltd. was formed in 1980 and is the largest electronics R&D organization in western Canada. It moved recently into a new $10 million laboratory adjacent to Simon Fraser University in Burnaby, B.C. The company is also establishing a Pacific Microelectronics Centre for the design, testing and packaging of custom LSI and VLSI integrated circuits that can be used in the parent company's telecommunications products. Wafer fabrication is to be done by the corporate affiliate, GTE

Microcircuits, in Tempe, Arizona, using an ISO-CMOS process licensed from Mitel. The custom microelectronics facility has been made available to universities and other companies in Canada for the creation of their own custom chips.

Optotek in Ottawa has a total staff of 45, of which 20 are involved in advanced products and product development. Its main product line consists of specialized low-volume optoelectronic products based on LED displays. It has a complete production facility, from basic epitaxial growth through fabrication to assembly and testing.

Optoelectronics Ltd. is a small company situated in Oakville, Ontario, with a well defined world market niche characterized by low-volume, relatively high-priced products and no direct competition. Its major product is a family of high-speed semiconductor detectors for the optical wavelength range. It also sells short pulse laser sources as a complementary product. Current sales are about $1 million a year. Although the company is small, it is very technology intensive and devotes a relatively large effort to research and development to develop new advanced products.

Siltronics Ltd. is a seven-year-old Kanata company with about 50 people. It produces bipolar integrated circuits for clients manufacturing electronic toys, test equipment, telecommunications equipment, electronic security equipment and radio paging equipment. Sales for 1981 were $4.5 million, primarily for export. The company moved into a new 2,500 square metre plant during 1982 as part of a major expansion effort.

Mosaid Inc.. in the Ottawa region, has acquired an international reputation for its capability in consulting and design services in integrated circuit technology. The company includes most major U.S. semiconductor device manufacturers among its clients. Sales in 1981 were about $1 million. It has recently indicated its intention of establishing a silicon device production facility.

CALMOS is a newly formed Canadian company that is establishing a number of custom integrated circuit design facilities in cities across Canada. This capability is based on technology to be licensed from a California based custom circuit company. The CALMOS design will be manufactured in California.

Other Canadian companies with semiconductor device products include Canadian General Electric (high current rectifiers and SCRs), RCA (Photodetectors), TPK (photovoltaic solar cells) and National Semiconductor (cadmium sulphide photodetectors).

As indicated in the above review, the integrated circuit industry in Canada is dominated by only two companies. Northern Telecom and Mitel have vertically integrated production capabilities in which they manufacture custom devices that are incorporated into their own telecommunications system products. Recently, both companies have made their in-house chip foundries available to outside users on a limited basis. The rest of this industry sector is characterized by smaller companies that have been able to exploit export market niches for special devices. A few of these also produce custom chips for their internal use. There is no Canadian manufacturer producing a broad range of standard semiconductor devices for Canadian firms that want to incorporate advanced semiconductors into their electronic products. This market is almost totally dependent on importing chips for their manufactured products. In 1982, Canadian companies imported $193 million worth of chips.

Standard off-the-shelf chips, while more readily available, limit design applications. Semi-custom or custom chips allow a manufacturer to produce unique features in a product. The economics of dense chips promote a move toward more custom-designing. As mentioned earlier, the microelectronic applications are projected to dramatically

increase the world semiconductor market by 1990. Recent reports indicate that, while the world's semiconductor manufacturing industry has increased production capacity, the supply of some widely used custom silicon chips is unable to meet demand. This could lead to a severe worldwide shortage of chip capacity about 1987. If these projections are borne out, securing a steady, reliable supply of custom chips will be a concern of many manufacturers. Industry experts fear that Canada's access to the most advanced chips may soon be seriously curtailed. Canadian companies are already experiencing delays of as much as 40 weeks in some cases in getting some chips, and other chips are virtually unavailable.

In order to secure a steady supply of chips, many smaller companies, particularly in the United States, are double ordering or triple ordering chips from suppliers. Many bigger companies are already protected against shortages by long-term arrangements with chip manufacturers or because of their in-house production capability like Northern Telecom and Mitel. The hardest hit are the semiconductor industry's newer customers, particularly those who depend on components on which suppliers make low margins. Emerging young entrepeneurial companies making products that depend vitally on microelectronics, such as personal computers, instruments, measuring devices and control systems, may be limited in their growth potential because semiconductor manufacturers are switching production capacity to more profitable components. This may further compound the problem of a short supply of chips.

In addition, the increasing trend to international trade protectionism could create a severe disadvantage for Canadian manufacturers, given that advances in microelectronics and the production of chips are being undertaken almost exclusively in other countries. In the extreme, the consequences of technological protectionism could potentially cause economic problems for all but a few of the largest

companies in Canada, because their product successes depend on imported chips and imported design aids.

It is tempting to conclude that Canada can go on importing the components and technology that are now so essential to the continued exploitation of market niches and to the opening of major new markets. Microchips are becoming so fundamental to emerging technologies that Ontario will not be able to compete without them, much less emerge as a winner. Walter Light, chief executive officer of Northern Telecom, has stated that without mastery of semiconductor technology, "no nation can hope for more than a peripheral existence." As the complexity of the components increases, a fresh approach to both their design and application is essential. The Canadian electronics systems industry may well need to be supported by a silicon component capability in Canada.

B. Computers

a) Developments and Applications:

The dawn of computers, or information processing machines, may be seen as one of the most significant events in the development of humanity. The massive, fast and accurate processing of data outside the human mind has enhanced our capability to deal with scientific, administrative and technical tasks of complexities previously unthinkable. For all practical purposes, the species "computer" is only 40 years old.

This amazing development, as discussed in the previous section, has been made possible by the equally startling progress in microelectronics achieved through silicon integrated circuits. Computers are also a major user of these integrated circuits and have contributed to the ever increasing demand for these units, which in turn make technology developments economically viable.

It is apparent that computer and microelectronic technologies enhance each other. However, there is a most important third ingredient that controls the system and defines its capabilities: software.

Software can be divided into four areas. Systems software controls the computer itself, moving data within the machine. Applications software comprises the programs that perform specific tasks. Such software packages are "products." Development software helps users or software companies create programs. Custom software is a product specially tailored for a particular user.

Software consists of data and programs. Programs define what operations should be performed on the data. The result is more data. This principle applies to all applications, be they the addition of two numbers or the operation of an insurance company. There is only an operational difference between programs and data. Physically, programs are also data and their respective imprints on a magnetic surface are not distinguishable from each other.

Programs control the actions of the hardware, most importantly in the central processing unit (CPU) of a computer. As a result of microelectronics, the CPU circuitry is so fast that even modest computers process millions of instructions per second (MIPS). Random access memory (RAM) is, like the CPU, made of integrated circuits, which provide access times measured in fractions of a microsecond (one millionth of a second).

Data can be measured by the number of characters it can represent. The equivalent of one character is often called a byte. To the CPU, data in RAM is like information in a file cabinet: it can be accessed immediately when needed. To access the next level in the storage hierarchy is like requesting a file folder by internal mail. Only the

smallest computers can afford to sit idly until that data arrives. Any multi-tasking or multi-user system will store away in RAM the information required to resume the present task, and switch to other tasks in the meantime.

With the increasing amounts of economically available processing power and storage capacity, larger and more complex tasks can be handled by software systems, which themselves tend to grow to economical rather than to functional limits. Making a computer program user friendly, fail-safe and flexible dramatically increases its size and complexity.

Providing products that are user friendly and more responsive to human needs is a large part of the requirement facing information systems designers and software developers today. End-user satisfaction is rapidly becoming a decisive competitive factor, especially as it relates to the person-machine interface. The video display terminal, the matrix printer, the ink jet printer and the computer keyboard are all examples of areas that are being investigated for improvement in the human factors area.

Software compatibility and portability, as well as the high development costs, are major issues for the future viability of many companies. Currently much of the software developed for specific hardware is not compatible or transferrable to other hardware. Therefore, if new equipment is not software compatible with a company's existing software, totally new software may be required. Software portability is more of a problem in mainframes than in microcomputers because systems software for mainframes is not as standardized.

To address the capabilities of visual or speech recognition and synthesis, to handle graphics data and to simulate physical events requires vast amounts of processing power and data storage. New concepts in computer architecture that aim at handling previously impractical or even impossible tasks are all based on the use of large and complex

software, which depends on the increasing hardware capabilities that the evolution in microelectronics provides.

Computers do not only appear as blue or gray boxes in air-conditioned rooms or in the dens of hobbyists. A respectable CPU can be produced on a single chip with a few more chips to provide memory and auxiliary functions. For simpler applications, these can all be placed on a single-chip microprocessor. Such computers or controllers have become part of most modern test equipment, automobiles, appliances, office machines and communications equipment. Powerful computers serve as engineering work stations to aid design in almost every discipline. Many small businesses are equipping themselves with data processing capabilities. This is all only a beginning.

b) Trends and Forecasts:

Foreseeable developments can be summarized in terms of the following two categories:

i) Do Old Things Better:

Trends in the production and performance of the computer and electronics industries during the next decade will be driven by an increase in the number of circuits that can be placed on silicon or other semiconducting material chips, the associated decrease in the costs of logic and memory, and software advances.

As the performance-cost ratio of silicon devices continues to increase, functions now performed by computers will become cheaper to implement, making this facility available to an ever widening area of applications in the office, plant and home. In particular, advances will be seen in the ability to compute, control, communicate and simulate.

Compute:

Computers will become part of every human activity involving the manipulation of numbers or data. The current trends will permit home computers of the equivalent capacity of an IBM 370 to be available for the home market before 1990, at a cost of a current home system of approximately $4,000. The price of small general purpose computers of comparable power has been dropping at an annual compound rate of about 25 percent. The average rate of improvement for the largest general purpose computers has been about 15 percent a year less than for comparable small machines because the newer large computers offer added functions as well as more computer power. At a time of serious economic problems, decreases in dollar costs are at least in part responsible for an annual increase in available computer power of about 40 percent, a rate that will probably continue for the next decade.

Even as further advances in computing speed, data storage capacity and cost effectiveness are being contemplated, a recently announced innovation will challenge the basic concepts of how computer capabilities are applied. This new development allows 10 trillion bits of digital data to be stored in an optical memory system. Read rates of five megabits a second and write rates of 30 megabits a second are made possible by acoustic/optic components in conjunction with focused laser beams. This capability is expected to almost entirely eliminate time-consuming queuing for information retrieval, reduce the amount of space required to store data by orders of magnitude, and increase the volume of stored information well beyond that of currently used magnetic storage tapes.

Control:

Control implies the manipulation of the physical world by processors. The availability of compatible families of devices to implement control algorithms for plants of every size and form suggests

that all new plants will be controlled by processors. The increasing use of microprocessors in automobiles is an example.

Communicate:

Silicon technology permits the implementation of complex communications techniques and protocols that would have been unattractive, from a cost point of view, a few years ago. Coupled with high bandwidth mechanisms such as fibre optics and transmission media such as satellites, it is inevitable that a society completely interconnected for communications will emerge.

Simulate:

This term is used to cover the vast array of software mechanisms for computer-aided manufacturing (CAM), computer-aided design (CAD) and computer-integrated manufacturing (CIM). The computer, with the appropriate software, can be used to undertake design simulations of a complexity that would have only recently been economically infeasible or occupied too much time. With these simulation models, new machines can be designed, businesses can be run and world models can be projected. It must be recognized that such mechanisms become an equalizer in that more and more businesses will have access to more sophisticated mechanisms to compete with each other. The importance of this increased ability to access, manipulate, correlate and assess vast bodies of data cannot be overstressed, for these functions are at the heart of business, industry and government.

It is forecast that the cost of logic and memory will continue to drop, thereby giving rise to revolutionary new products. For example, IBM has a voice-activated typewriter in its laboratory today. Currently, the problem is that such a typewriter takes an enormous amount of memory. However, as the cost of memory continues to drop, an entirely new way of interfacing with machines will emerge.

Software is coming to be considered as the "new wealth of nations" and the area of maximum added value. In the emerging new international economic order, advanced industrial countries are reacting to the erosion of their traditional manufacturing sector by adopting new technologies in mature industries and creating entirely new markets and service industries. They are focusing on selected proprietary technology niches, such as software, to obtain strategic exports and create employment, rather than on traditional commodity products.

The trend in the software business is moving away from companies producing their own programs internally and toward publishing third party software produced by talented outside authors. By making this move, software companies can concentrate on gaining a competitive advantage through marketing and distribution control. A further trend is the wave of mergers and acquisitions by larger software companies seeking the strengths of smaller companies, which are increasingly finding the marketing of software too expensive to remain independent.

As the personal computer software industry matures during the next five years, there is expected to be a three-way split in the market: hardware manufacturers will focus on basic programs such as word processing; independent software houses will develop more-sophisticated, higher margin products for the after-purchase market: and publishing houses will dominate the mass market for home education, entertainment and simple business programs.

In a typical information system setup, that is, a hardware-software combination, software costs increased to 50 percent of the total system cost in 1980 and are expected to reach 70 percent by 1990. The 1983 study An Overview of the Canadian Software Industry, by Evans Research Corporation, estmated that 1983's $11.1 billion software market in the United States will grow to $29.9 billion in 1988. Applications software is the fastest growing segment of the market. It is

expected to have an average annual growth of 34 percent to 1990. Evans Research Corporation predicts an average annual growth rate of 28 percent for the software industry in Canada to the end of 1990. By the end of 1983, it expects the market to reach $1 billion, and $5.4 billion by the end of 1990.

ii) Do New Things:

By the end of the 1980s, the impact of artificial intelligence will begin to appear in almost all computer-related devices. This will see the advent of a whole new range of self-sufficient devices.

Artificial Intelligence:

There is, at present, a worldwide effort to understand the mechanisms of artificial intelligence (AI). The effort here is to simulate the human capacity to draw inference from data or, indeed, to make the intuitive leaps that structure the world into new shapes. It is significant that some of the best minds in the world are now turning their attention to this problem - it is the new frontier, in which Nobel prizes will be awarded in years to come. This research, coupled with new computer architecture and their computational capacity, should begin to produce significant results before the end of the 1980s.

By the year 2000, this aspect of computer technology may well have reached the point of being clearly the most important influence of computers in all areas of society.

Speech Recognition:

An early result of AI will be the recognition of human speech. This will be a major milestone in the development of human interfaces with computers - making computers accessible to all levels of society.

Individual word recognition systems are now available with vocabularies of a few hundred words. Short phrases of connected words

should be available within a year. Speech recognition of reasonably structured language should occur within 10 years.

Human Interfaces with Computers:

One of the potential applications of great commercial value is to interface humans with computers. The goal here is to ease the ability required to use computers by removing the necessity of formal programming languages. Instead of programming as it is known today, a statement of requirements will be all that is necessary: the program will be generated by the machine and executed.

Intelligent Robots:

Both stationary and mobile robots, augmented by voice input/output, vision and reasoning power, will be available for manufacturing and for other societal functions such as home care of the aged or infirm. The impact of industrial robots is already a reality. Their influence will be increasingly pervasive. The design of assembly lines, offices, homes and hospitals will become altered to accommodate robots.

c) Canada's Position in the Computer Industry:

Both computer hardware and software will capture increasing shares of the goods and services produced by an industrial society. The importance of successful participation is increasingly being recognized by government and industry in other countries. The prime example of strategic planning and cooperative implementation is being set by Japan, with its development of "fifth generation" computers. Any country that intends to maintain an industrial base will also need to formulate and execute a viable strategy.

There are niche opportunities for Canadian companies to develop special application software running on foreign hardware and also for

specialized hardware with or without software. To become a world market factor in a major area requires a significant concentration of capital and scientific and commercial talent. The joint development of large software systems, hardware architecture and microelectronics implementation will be necessary and will provide a sizable management challenge.

The University of Waterloo has an international reputation in software development. It was recently awarded $1.6 million, the largest single strategic grant ever awarded to a Canadian university, to develop a very large scale integration computer research program. The long-term objective is to advance Canadian capabilities in high technology and computers.

C. Optoelectronics

a. Fibre Optics:

i) Developments and Applications:

Fibre optics technology involves transforming information into beams of light and transmitting them along glass fibre cablè. Major application areas include voice and data communication systems, cable television, remote terminals-to-host computer linkups, process controls, power company line and highway monitoring systems, automotive systems, word processing and local area networks.

In the telecommunications area, fibre optics transmission systems have expanded rapidly in use from trunk lines to local loops, and are gaining an entry in the intercity and international network markets as the technology advances and the price of equipment drops. The worldwide market for fibre optics systems has been estimated to reach $1.4 billion by 1986, with continued strong growth into the next decade. Seventy percent of the value produced will be in fibre cable and 30 percent in electric terminal equipment.

The introduction of fibre optics is being driven by the need for expanded capacity to meet increasing demand for both data communication and voice traffic. Fibre optics systems provide this capacity and permit expansion to occur at a much lower cost than conventional technology. As a result of its small physical dimensions, fibre optics can provide growth within existing underground conduits and ducts in office buildings.

For communications systems, fibre optics technology has five major advantages over traditional copper cable networks:

- Fibre optics can transmit much larger quantities of information. Currently, a pair of glass fibres can carry 140 million bits of information a second (or 2,000 voice conversations simultaneously). It is expected that future systems will be able to carry 500 million or more bits of information a second (or 8,000 voice conversations simultaneously).
- Fibre optics can produce a much higher quality of transmission, as it is free from electromagnetic interference. Future technical improvements in glass fibres and the quality of laser signals are expected to further enhance the signal quality of fibre optics systems.
- Fibre optics systems, like any other wideband system, can carry several different forms of data, from voice transmissions to pictures.
- The fibre optics system has several cost advantages: lower systems dimensions and weight; lower equipment and maintenance costs due to longer spans between repeaters: lower material costs (it has been estimated that fibre optics prices will drop by one-third during the 1980-85 period); and its performance advantages, which lower unit costs substantially.

- It has low transmission loss, requiring fewer repeaters in order to boost its signals over long distances. For example, whereas copper cable requires a repeater device each six to eight kilometres, fibre optics systems only require one device each 30 kilometres.

ii) Other Private and Public Sector Support:

Companies most active on the international scene in fibre optics include Northern Telecom (Canada); ITT and Western Electric (United States); and Nippon Electric, Oki Electric and Fujitsu (Japan). The most active in the U.S. market include American Telephone and Telegraph, Digital Communications, Times Fiber and Siecor (a joint venture between Siemans of West Germany and Corning Glass of the United States).

The British government has committed $60 million over the next five years to encourage fibre optics R&D, providing 25 percent grants to eligible projects. Assistance is provided for R&D itself, capital expenditures for research facilities and equipment, and feasibility studies for fibre optics applications.

In Japan, the Ministry of International Trade and Industry subsidizes research and development projects in selected next-generation technologies, including eight concerning optoelectronic technology. It has also set up the Optoelectronic Industry and Technology Development Association, consisting of 161 corporate members. The goals of the association are to plan the future activities of the Japanese optoelectronics industry, diffuse technical knowledge and promote international cooperation.

It is reported that West Germany and France have also committed funds for the development of fibre optics technologies.

iii) Canada's Position in Fibre Optics:

Canada is in the first rank of fibre optics producers in the world. The following is a list of recent major Canadian commercial developments:

. In June, 1983, Bell Canada announced that fibre optics technology will begin to replace copper wires in the inter-office trunk network in Ontario and Quebec. Cost savings to Bell are expected to be 20 percent to 25 percent, due principally to the performance advantage of optical transmission systems as well as lower maintenance expenses. Total conversion to fibre optics is to occur over several years. In 1986, fibres are scheduled to be installed for telephone connections between central office and apartment buildings, offices and subdivisions.

. In June, 1983, Saskatchewan Telecommunications announced plans to expand its fibre optics network to 15 additional communities. This expansion will add to what is already the world's largest commercial fibre optics network and will carry telephone, cable television and videotex systems. Northern Telecom has received an initial $22 million contract from Saskatchewan Telecommunications for this work.

. As of July 1, 1983, Northern Telecom (Mississauga) had designed, manufactured and installed 132 systems in Canada. The company has a dedicated fibre optics plant in Saskatoon and expects further growth in this field, especially in U.S. markets. Northern Telecom signed a $100 million contract in January, 1983, to supply MCI Communications Corporation of Washington with fibre optics cable for use in the long-distance telephone network between New York and

Washington. It has been reported that the contract could reach $200 million in the next four years.

- Agencies of the Manitoba government, along with private companies, have committed $9.6 million for a two-year test of fibre optics communications to selected rural households in the province.
- Foundation Instruments of Ottawa has developed terminal equipment and sold fibre optics systems in Canada and Mexico.

b) Lasers:

i) Developments and Applications:

"Laser" is an acronym for "light amplification by stimulated emission of radiation." A laser is a device that uses an energy source and a lasing medium (that is, a material that gives off its own light when stimulated) to amplify light waves and generate an intense and highly concentrated beam of light. Laser light differs from conventional light because it is "coherent." This means it has a single wavelength and uniform direction, which gives it a number of unique capabilities that can be used in both industry and basic research.

Laser light can travel as a beam over long distances and can transmit light in virtually straight lines, send information at unprecedented speeds and concentrate an intense amount of energy on a small surface area.

Laser technology is being used in industrial, scientific, medical and semiconductor applications. Industrial applications are centred on product marking, package coding systems and materials processing for heat treatment, welding, drilling and cutting. For example, the contamination-free laser marking process has raised productivity and quality in the manufacture of semiconductors. The

various materials processing functions performed by laser tools can be integrated with computer numerical control (CNC) production systems in order to precisely regulate the performance of tools and thereby further increase product quality and reduce waste in manufacturing. In the near future, laser materials processing will be further integrated via robotics into flexible manufacturing systems.

Scientific applications are centred on spectroscopy (to measure the molecular structure of materials) and photochemistry (to alter the molecular structure of materials). Two examples of photochemical applications are the use of lasers in the purification of silicon for the manufacture of semiconductors and the use of lasers in the production of vitamins. For example, the National Research Council, using a laser produced by Lumonics (of Kanata), recently made a significant scientific breakthrough by tripling the efficiency of vitamin D production. Lasers are also used in plasma physics research, with anticipated application in harnessing nuclear fusion.

Medical applications include cataract surgery, photocoagulation of blood, inner ear surgery and tumor detection. In cataract surgery, light severs eye membranes while passing through the lens of the eye without inflicting damage. This technique has reduced what was once a four-hour surgical operation to an out-patient procedure that can be performed in minutes and without an anaesthetic.

Semiconductor lasers are a class in their own. These are tiny chips of gallium arsenide-based components that transform electrical energy into visible or infrared "light." They are used in fibre optics systems, in videodisc players and in optical disk data storage systems.

ii) Ontario's Position in Laser Technology:

A small number of Ontario companies are active in the laser area, including Lumonics (Kanata), Ultra Lasertech (Mississauga) and

Northern Telecom (Kanata). Lumonics is the third largest commercial manufacturer of lasers in the world. Through the 1982 acquisition of J.K. Lasers in the United Kingdom, the company added technology complementary to its previous product line. The acquisition gave Lumonics laser drilling, cutting and welding products to combine with its product marking system used in materials handling, quality control and packaging. Lumonics' export ratio has been reported as 90 percent, with 1982 sales in the U.S. market up 60 percent and in the Japanese market up 100 percent from their levels of a year earlier. Lumonics has recently announced an $11.5 million order from a distributor in the United States for laser surgical systems.

Ultra Lasertech is a small company manufacturing lasers with applications in spectroscopy, optical communication, air pollution detection and monitoring, materials analysis and testing, among other areas.

Northern Telecom produces semiconductor lasers for its fibre transmission systems as well as for general sales.

D. Biotechnology

a) Developments and Applications:

The popular conception envisions biotechnology as a radically new science where biological systems are manipulated to create novel living organisms. In fact, biotechnology is an extension and combination of many existing scientific disciplines, including cellular and molecular biology. microbial genetics, biochemistry, physics, chemistry and various process engineering specialties, to name but a few. As defined in the recent federal task force study "Biotechnology, a Development Plan for Canada," biotechnology is "the use of a biological process, be it via

microbial, plant or animal cells, or their constituents, to provide goods and services."

Some of the goods or services have been available for centuries: biotechnology has long been exploited through the techniques of fermentation in the production of alcoholic beverages and foods such as cheese. In the early part of this century, biotechnology gave rise to the production of several useful vaccines and other products of industrial fermentation. More recently, rapid developments in the fields of microbiology, fermentation technology and chemical engineering have resulted in the production of a variety of useful products, including antibodies, vitamins and amino acids.

New biological techniques have emerged at a critical time in the economies of the developed countries because of the dramatic decline in traditional manufacturing industries. Consequently, these techniques are being pursued as part of the answer to creating replacement job opportunities and new wealth.

Biotechnology research and product development is expanding rapidly. The diffusion of biotechnology into practical applications will inevitably bring significant changes to a broad range of industries. Applications are as diverse as crop improvement, diagnostic medicine, animal health, pest control and food processing. The following is a brief listing of the principal applications within several major industrial sectors.

i) Agricultural Applications:

The agricultural industries that will be affected by new biotechnology in the coming years include the seed industry, the agricultural chemical industry, veterinary vaccines, animal hormones and hormone analogs, and animal nutrition supplements such as vitamins and amino acids.

By the end of the decade biotechnology is expected to have the greatest impact on the animal vaccine and hormone markets, with new products based on genetic engineering becoming available. By the early 1990s the most substantial impact will be in the larger sectors of seed and crop protection. As much as 20 percent of North American seed sales in the early 1990s may embody, or be the result of, applications of new biotechnologies now being developed. Crop protection is among the novel features most likely to be incorporated.

Application areas include:

- development of microbial strains that improve plant growth characteristics;
- plant cell cultures to selectively generate plant-based products;
- improved plant strains through genetic engineering to increase yields and stress resistance:
- production of biodegradable pesticides, herbicides, growth hormones and fertilizers by fermentation;
- production of animal feeds and supplements (e.g. single cell protein, vitamins) by fermentation;
- development of protein-based animal hormones and vaccines;
- genetic engineering of animal species to increase yields and stress resistance;
- biotechnology-based test and selection procedures for use in breeding of plants and animals.

ii) Food Industry Applications:

All facets of forefront biotechnology, recombinant DNA, hybridoma, tissue culture and immobilized proteins have applications to the food industry. These applications generally have advantages in

decreasing costs, assuring constant supplies of raw materials, improving shelf life and enhancing commodity products.

Application areas include:

- improved fermentation processes for wine, beer, vinegar and yogurt;
- production of valuable enzymes, flavors, sweeteners, vitamins, amino acids, gums and other food additives through fermentation techniques;
- microbial-produced single cell protein as human foodstuff;
- conversion of organic waste into food products through microbial action.

iii) Chemical Applications:

There are a significant number of chemical products currently produced by standard chemical, fermentation and extractive processes that will be affected by biotechnological approaches in the next 10 years. However, there are a number of barriers to the widespread implementation of advanced techniques. For example, commodity chemical applications are limited by the current decreasing price of petroleum feedstock, making it harder for the biomass feedstocks to compete.

Application areas include:

- fermentation using microbes as a route to raw materials and plastics;
- monoclonal antibodies (selectively binding proteins) in chemical purification;
- plant cell cultures to produce chemical products;
- enzyme systems to produce chemical products.

iv) Mining Applications (Resource Recovery):

A key to mining applications is the lower energy requirements of bacteria compared to current methods. In the United States, about 20 percent of copper is mined through biological leaching, a process invaluable in the mining of lower grade ores. Hopes are that microbial systems could open up previously unavailable reserves as well as reduce the cost of recovery from existing sources.

A consideration in the recovery of oil is the fact that Alberta has as much heavy oil or more than the Middle East has light oil. In these circumstances, bacteria can be used directly to modify the flow characteristics of heavy oil or indirectly as lubricants during drilling operations.

Application areas include:

- use of microbes in the leaching (low energy removal) of metals (e.g. copper, uranium) from low-grade ores;
- genetic engineering of microbes to improve extractive properties;
- use of microbes to modify heavy oils (e.g. tar sands) to facilitate collection;
- microbial produced polymers as lubricants (e.g. drilling mud);
- the breakdown of polluting by-products through microbial action.

v) Health Care Applications:

It is likely that the health care sector, because of its past experience in biological products, will be the most affected by biotechnology in the next decade. The pharmaceutical industry was among the first to take up modern biotechnology, as part of its continuing search for new and more efficient products and processes.

Application areas include:

- improved fermentation processes for production of vaccines, antibiotics, hormones and drugs;
- genetic engineering of micro-organisms to produce desirable medical products:
- use of enzyme systems in pharmaceutical manufacture;
- monoclonal antibodies in diagnosis, treatment and research of disease:
- monoclonal antibodies in large scale purification systems:
- gene therapy in the treatment of hereditary diseases;
- creation of new cell types through cell fusion and hybridomas:
- miscellaneous new techniques resulting from biotechnology research (e.g. microencapsulation as a method of drug administration).

vi) Energy and Waste Treatment Applications

Industry is continuously seeking means of rendering waste effluents environmentally inert. Monoclonal antibodies have been proposed as one solution based on new biotechnology, whereby their ability to bind and aggregate can be used to remove hazardous elements of waste water. In some ideal cases, bacteria might be used to break down similar wastes into commercially valuable by-products.

Application areas include:

- microbial reduction of waste into useful by-products:
- fermentation production of ethanol, methane and hydrogen from biomass;
- use of biological binders (e.g. monoclonal antibodies) in effluent treatment:
- agricultural applications for the production of cheap biomass as raw material.

b) Other Private and Public Sector Support:

Due to the high growth potential of industries in biotechnology, international competition is formidable, with countries like West Germany, the United Kingdom and Japan having invested substantial sums into research and development during the past decade. International Market Surveys recently prepared profiles of forty different countries with established or planned efforts in biotechnology.

The case for government involvement in this field is strong. It is an area that requires major up-front capital investment, but where profitable returns may take a minimum of five to ten years. Few private Canadian investors are positioned to finance such projects. Chart 1-1 provides an international comparison of government support for research and development efforts in biotechnology.

CHART 1-1

CURRENT ANNUAL RATES OF PUBLIC SPENDING ON BIOTECHNOLOGY R&D: 1982

COUNTRY	BIOTECH R&D (in millions)	BIOTECH AND RELATED R&D (in millions)
U.S.A.	200	550
Japan	50	NA
Total EEC	146	355
West Germany	36	132
France	31	84
Britain	46	59
Italy	13	34
Holland	10	26
Belgium	7	14
Other EEC	3	6

Source: EEC Commission, 1983.

In the United States more than 250 start-up companies have been established since 1977, most of which are privately held and funded, and more than 200 major industrial companies are developing biotechnology opportunities. Billions of dollars of government and private funding have been allocated to development of biotechnology, with additional sums coming from tax-sheltered R&D partnerships purchased by high income investors. American researchers represent about 50 percent of the total world effort in biotechnology R&D. There has also been extensive collaboration between government-funded research institutions and biotechnology companies developing commercial products. This has tended to shorten the lag time from research lab to commercialization.

In Britain, the government has allocated $32 million for three years for the development of biotechnology. More than 20 new start-up companies have appeared in Britain since 1978 and many major industrial corporations are involved in biotechnology research. The government is encouraging a number of cooperative strategies between research and industry.

In France, industry is spending more than $1.6 billion a year on biotechnology. The government has pledged $13.5 billion by 1985 to R&D. A substantial portion of this funding is for biotechnology, with the primary focus on biomass conversion, agriculture, clinical diagnostics and the immunizations activity.

In Japan, biotechnology has been rated the number one growth potential industry by 662 Japanese companies. The Japanese Ministry of Trade and Industry estimates Japan's biotechnology market at $16.8 billion by the year 2000. Significant numbers of Japanese companies are involved in joint ventures, equity purchases and research contracts with U.S. biotechnology companies. Governmental agencies allocated $33.2 million to biotechnology R&D for 1983, an increase of 5.8 percent over 1982's allocation.

In Korea, genetic engineering is a prime industrial development target for South Korea's five-year economic plan. The government has allocated $2 billion to R&D projects, with a major portion devoted to genetic engineering. A joint planning committee of 14 industrial companies has been formed to develop biotechnology opportunities for South Korea.

In West Germany, the federal government budgeted $25 million for biotechnology in 1983. A West German company invested $50 million in molecular biology at the Massachusetts General Hospital in the United States. The federal Ministry for Research and Technology has become the driving force behind industry-academia projects, with a focus on medicine, agriculture and food processes.

The United States, Britain and France appear to have a leading edge in the biotechnology field. Given the significant allocation of funds to a variety of projects, it would appear that these countries are committed to retaining this advantage. Canada, with 14 companies in the field, appears to be behind. However, in view of the five- to ten-year time frame before the biotechnology developments have an impact on industry, it would not appear too late to develop in the field. For example, the impact on the agriculture and forest products fields is not likely until the 1990s.

c) Ontario's Position in Biotechnology:

In Canada there appears to be a "practically non-existent biotechnological industrial base," according to the Ministry of State for Science and Technology (MSST). An MSST report recommended a 10-year national biotechnology development plan. To date, very few concrete steps have been taken, with the possible exception of the government of Ontario's investment, along with CDC and Labatts, in Allelix Inc.

i) Private Sector:

Allelix (Mississauga):

- research and development leading to commercial products for agriculture and industry;
- soil microorganisms, improved plant species, monoclonal antibodies in diagnostics and fermentation;
- funded by CDC, Labatts and the Ontario government for a total of $90 million to $100 million over 10 years.

Bio Logicals (Toronto):

- research and development of commercial products in pharmaceuticals and health care therapeutics;
- anti-viral herpes treatment, nucleotide synthesis;
- widely held public company with capital reserves of about $9 million and joint project with Alberta government.

Connaught Laboratories (Toronto):

- research and development, sales and marketing in medical diagnostics and therapeutics;
- insulin from recombinant DNA, veterinary vaccines, rabies vaccines and factor VIII for hemophilia;
- controlled 100 percent by CDC after purchase from University of Toronto;
- holds almost 100 percent of Canadian insulin market.

Bio-Hol Development (Toronto):

- research and development in biomass fermentation to produce energy (alcohol);
- zymomonas mobilis as a fermentation microbe;
- funded by George Weston Ltd. and Ontario Energy Corp. as well as federal/provincial grants; total $5.5 million.

Stone and Webster (Toronto):

- biomass conversion to produce ethanol using genetically engineered yeast;
- project engineering firm, Canadian subsidiary of U.S. parent.

John Labatt Ltd. (London):

- research and development, commercial production of high fructose corn syrups as commercial sweetener;
- fusion of yeast strains to improve fermentation properties for beer;
- large, diversified, $380 million equity base public company.

Weston Research (Toronto):

- research and development in areas related to food processing and forest products;
- research on microbially produced gums.

ii) University Initiatives:

Carleton:

- use of monoclonal antibodies in plant research;
- nitrogen fixation studies;
- plant cell cultures and genetic engineering in plants.

Guelph:

- proposal with Waterloo for Centre for Biotechnology;
- research planned using monoclonal antibodies in plant research;
- monoclonal antibody-based tests to detect fish virus;
- joint Centre for Toxicology with University of Toronto;
- improved plant species;
- plant tissue culture.

McMaster:

- monoclonal antibodies for the detection and treatment of herpes virus and diagnosis of other diseases;
- recombinant DNA in the production of hormones.

Ottawa:

- fermentation pilot plant:
- recombinant DNA techniques and molecular genetics in plants:
- studies on wine cultures, nitrogen fixation.

Queens:

- industrial scale production of monoclonal antibodies;
- research on hybridoma techniques:
- monoclonal antibodies in diagnosis of disease.

Toronto:

- monoclonal antibodies in the treatment of sewage effluent and diagnosis of disease;
- joint Centre for Toxicology with University of Guelph;
- monoclonal antibodies in the purification of insulin with Connaught.

Waterloo:

- Centre for Process Development designing commercial biotech systems and course in biotechnology:
- microbes in the leaching of metals from ores:
- studies on single cell protein, biomass conversion to energy.

Western Ontario:

- studies on bacterial genetics;
- treatment of industrial waste water with biologicals;
- studies on fermentation processes;
- microbes in the recovery of heavy oils;
- genetic improvement of corn species;
- monoclonal antibodies in the diagnosis of disease.

Windsor:

- plant cell cultures.

York:

- genetic studies in cloning and recombinant DNA;
- insect pheremones in pest control.

E. Advanced Manufacturing Technologies

a) Developments and Applications:

Manufacturing represents one of the largest single application areas for many new computer-based technologies. As in other application areas, the requirements must be matched to the tools evolving from the technology. Successful implementation of computer-aided design and manufacturing (CAD/CAM) demands, above all, the integration of user requirements with the capability of the technology.

The tasks required in order to design and manufacture a product use and, in turn, generate product information. Computers are ideal for the generation, storage, retrieval and revision of such product data. The lack of an affordable and effective product information system has been a significant contributor to manufacturing ineffectiveness.

Unlike financial system requirements for which there are standards determined by tax laws and accounting practices, there are no generally accepted standards for production systems. As a result, CAD/CAM systems for individual production tasks have been developed as a response to particular requirements of particular industries. Initial users of CAD/CAM were in the aerospace and microelectronics industries. The users and the CAD/CAM vendors jointly expanded the technology from what initially provided drafting assistance to what is today an impressive list of tools.

Highlights of the CAD/CAM tools are as follows.

Computer-Aided Design (CAD): Interactive graphic work stations allow the two-dimensional or three-dimensional geometries representing parts to be created, displayed and stored. Preprogrammed design rules and tests aid in the early detection of design errors.

Computer-Aided Manufacturing (CAM): Production facilities are making more use of computer-based manufacturing equipment. Instead of "hard" automation with dedicated equipment, programmable, flexible manufacturing systems (FMS) are being implemented.

NC (numerically controlled) machine tools, robots, programmable controllers and computer-aided inspection equipment are some of the many new-generation manufacturing tools. These tools all need to be programmed based on the geometry and material of the part.

CAD/CAM application programs that assist in the generation and verification of the programs for the manufacturing equipment are evolving. Some CAD/CAM systems can be used to drive the production equipment directly.

Group Technology (GT): Group technology has been called the glu that holds CAD/CAM together. It is the grouping together of similar part for more practical and efficient treatment in design and manufacturing.

Computer-Aided Engineering (CAE): Once captured, the product geometry can be used for the basis of a computer simulation of the behavior of the part when subjected to forces, temperature and age. This significantly improves reliability and reduces the need for costly prototypes and real life testing.

Computer-Aided Process Planning (CAPP): The selection of appropriate manufacturing methods and the determination of human resources and machine resources to produce the product are the key inputs to the production control and cost control systems. Computer assists that make use of the product data resource standards and previously created process plans are being applied and are continuing to evolve.

The following are the key issues driving the application of CAD/CAM technologies today.

Computer-Integrated Manufacturing (CIM): The significant productivity improvements in the application of CAD/CAM tools occur with the convenient access of each CAD/CAM tool to a common data base of active as well as historical designs, analysis, process plans and bills of materials. This CAD/CAM data base can then furnish and capture all the information requirements during actual production. This interactive production information system has been demonstrated as the key in improving deliveries, reducing production costs and cutting inventories.

32 Bit Work Station: The evolution of the 32 bit intelligent work station has brought the entry level cost of CAD/CAM within grasp of small- and medium-size businesses. This powerful and low cost work station will also be a key driving force as CIM evolves and the number of terminals expands.

Robotics: The future of robotics includes intelligent robots that will incorporate voice command and response in many applications. This will be combined with more sophisticated visual and touch sensors to produce a quantum leap in the functional abilities of the robot.

Data Base: One major roadblock to the path of CIM is the lack of adequate software tools to manage a large product data base containing geometric as well as text data items. The initial data base products are now being field-tested.

Computer System Integration: No one vendor has the complete solution. The automatic factory requires the interconnection of different computers, many of which use different formats to represent the data. Although some hardware standards for interconnections have evolved, the exchange of geometric data between different computers is by no means an established procedure. An initial geometric exchange standard (IGES) has been proposed and most major CAD/CAM vendors are actively developing software to support this standard.

With Ontario industry heavily committed to the supply of auto parts and the auto manufacturers actively pursuing plans to communicate CAD data electronically to their suppliers, the IGES is a most important issue for Ontario industry.

b) Other Government Support:

Government support activities outside Canada are generally centred on the following policy objectives: encouraging application, reducing the perceived risks of application, stimulating domestic production of flexible automation equipment, and promoting basic research and development in the field. A survey of these support activities reveals the following.

The Ministry of Research and Technology in France is encouraging advanced manufacturing through programs aimed at design, manufacture, distribution and use. The ministry has established an Interagency Robotics Committee whose objectives are being pursued in three phases: short-term (less than two years) to strengthen existing research, public

and private: medium-term (two to five years) to devise a comprehensive robotics program covering all key sectors of the economy, with the special aim of making French manufacturers more competitive internationally: long-term (five to ten years) to develop a French robotics production industry capable of generating significant export earnings. The Robotics Committee has been allocated $350 million for the years 1983-85.

In 1980, the Japanese Ministry of International Trade and Industry (MITI) helped establish the Japan Robot Leasing Company (JAROL), a consortium of 66 Japanese companies, including robot producers. JAROL leases robots on favorable terms, mainly to small- and medium-size businesses. Sixty percent of the operating funds are financed by low-cost loans from the Japan Development Bank, with the remainder originating with the Long-Term Credit Bank, the Industrial Bank of Japan and various city banks. JAROL has also started discussions with MITI to begin leasing robots overseas, a move that would further diffuse the technology while strengthening the position of Japanese robot producers.

In addition, the Small Enterprise Loan Corporation provides loans at below-market rates to small- and medium-size companies for industrial robots that release workers from hazardous working conditions. Until March 31, 1983, Japan offered accelerated depreciation for robots of a 10 percent additional write-off during the first year on top of the normal 40 percent capital cost allowance for industrial machinery.

MITI is also sponsoring the six-year Flexible Manufacturing System Project, a consortium of twenty companies, which is due to complete its work in late 1983. Japanese companies purchased more CAD/CAM systems in 1983 than the total for the rest of the world.

Over the period 1981-85, the Swedish Board for Technical Development is providing $41 million for R&D on CAD/CAM and robotics. The board, in conjunction with the Swedish Association of Mechanical and

Electrical Industries, is sponsoring another four-year (1981-85) research program totaling $14.8 million. Sweden also has plans to set up development centres to promote diffusion of advanced manufacturing technology to small- and medium-size companies.

The Netherlands is preparing a program to stimulate the adoption of flexible automation by offering low-interest loans for investments that apply it in new ways for Dutch industry.

In the United Kingdom, selective support for robotics applications is provided in the form of consulting services and/or grants of up to one-third of eligible costs. Additionally, the government has provided $3.7 million for the development of new robots. The CAD/CAM Awareness Program, directed at the mechanical engineering industries, and the CAD Awareness Program, directed primarily at the electronics industries, have sponsored practical demonstrations, management seminars and information services. Funding is reported to have increased during 1983-84 from $1.1 million to $3.3 million.

Other government support programs are under way in Australia, West Germany, Finland, Norway and Switzerland.

c) Ontario's Position in Advanced Manufacturing:

In Canada, computer-integrated manufacturing (CIM) is still an emerging concept. A number of Ontario-based firms are actively pursuing different sub-segments of this area, but the impact of these technologies on the manufacturing sector is just beginning. The lower intensity of robot use in Canadian manufacturing as compared to the manufacturing sectors of other advanced industrial countries is documented in Table 2-6 of Chapter 2. As well, the application of computer-driven automation in the Ontario automobile, clothing, footwear, machine tool, moldmaking and warehousing industries is described in Chapters 2 and 3.

F. Advanced Materials

a) Technology Developments and Forecasts:

Virtually every engineering endeavor becomes materials limited. The development of high performance materials is critical in almost all technological advances. Industries as different as computers and automobiles invest heavily in materials research. For example, silicon is the most important material in use in microchips and as such is the foundation for future developments in this area. It is quickly becoming impossible to build tomorrow's technologies with today's materials; rather, it is only with the materials of the future that it will be possible to develop the technology of the future.

For the purpose of this review, advanced materials have been divided into the following six categories: steels; non-ferrous metals; superalloys; special-duty materials: non-metallics, including plastics, ceramics and composites: and semiconductors. This section covers progress, breakthroughs and predictions for the next decade in each area.

i) Steels:

Technology advances will produce:

- tougher and stronger plates and tubulars:
- more-machinable and/or formable bars and billets;
- economical clad materials:
- super-strong stainless with exceptional corrosion resistance:
- cobalt-free maraging steels.

ii) Non-Ferrous Metals:

New developments will result in:

- aluminum-lithium alloys;
- prealloyed aluminum powder metallurgy materials;

- a breakthrough in the use of magnesium in the automobile industry;
- an expanded industrial market for titanium and its alloys;
- new beryllium coppers with increased strength and electrical conductivity;
- greater use of zinc-aluminum alloys as substitutes for bronzes, aluminum and cast iron;
- rapidly solidified alloys with superior mechanical properties and high temperature corrosion resistance.

iii) Superalloys:

The use of cleaner metals and new processes will produce:

- nickel-base alloys with superior properties for hostile production environments such as deep sour gas wells;
- new alloys for use as turbine engine blades;
- a new series of iron-base and nickel-base superalloys that are wear resistant and reduce the use of strategic elements.

iv) Special-Duty Materials:

Trends are in the direction of:

- cladding of cheap iron-based material with corrosion resistant refractory metals by electrodeposition;
- nickel-zinc and zinc-chloride battery systems;
- a lead-compound additive to asphalt for reduction of paving cracking;
- corrosion-resistant tantalum-columbium alloys for chemical process equipment;
- molybdenum substitution for replacement of a sizable fraction of tungsten in tungsten carbide tool steels;

- metallic glasses for use in sensor, power transmission and structural application.

v) **Non-Metallics:**

Developments include:

- synthesis of electrically conductive polymers:
- silicon carbide-aluminum composites with properties approaching those of titanium;
- new ceramic materials including silicon carbide, silicon nitride and zirconia, which could lead to a ceramic diesel engine;
- highly conductive ceramics as inert electrodes in molten salt electrolysis cells, which would revolutionize the way Al and Mg are made;
- ceramics powder synthesis by gas-phase laser-driven reactions to give rise to an entire generation of structural ceramics for use in internal combustion engines and turbine blades in stationary and transportation applications:
- ion selection sensors as the basis for a major breakthrough in chemical process control:
- ceramic/metal composites and ceramic cladding on metal substrates;
- high temperature polymers with service temperatures to 600°C:
- ion selective polymers for use as separators in high energy density batteries:
- high purity fibre optics for low loss transmission allowing long distance communication and data links.

vi) Semiconducting Materials:

Several breakthroughs will have a strong influence on the introduction and use of materials such as:

- GaAs (gallium arsenide) for microwave and millimeter wave high-speed integrated circuits; also, as a substrate for the thin-film deposition of GaAlAs, which can act as a high-speed transistor and as a more efficient solar energy coverter material;
- InP as an alternative to GaAs in high-speed data processing devices and as a near-infrared imaging device;
- lead-tin telluride and mercury-cadmium telluride as detectors in the thermal infrared;
- Josephson junction devices for use in supercomputers.

b) Areas of Application:

Selected applications are identified in this section to give an indication of their potential diversity.

i) Steels:

Applications for clad steels are expanding because of the increasing demands for improved erosion or abrasion resistance and better fabricability at lower total costs. It will be possible in the near future to produce almost any combination of high alloys bonded to a structural or pressure vessel carbon in low alloy steel. This means, for example, that nickel-based superalloys can be replaced with more economical clad products.

Many auto parts will be made from carbon steel instead of alloy steels and heat-treated by more energy-efficient methods.

The use of galvanized steels for improved protection against perforation and structural damage by corrosion in the automobile industry

is predicted to rise by 33 percent to 83 percent a year depending on the type of coatings specified. These steels will replace the use of prepainted steels.

In 1980, galvanized steel framing usage was 400,000 tons. Market projections point to two million tons of galvanized steel framing for use annually by home-builders by 1990. The key to the anticipated growth is a 20 percent reduction in the cost of materials and labor compared with wood.

ii) Non-Ferrous Metals:

New automotive industry alloys will provide 20 percent reductions in both thickness and weight. Applications will be in the air-conditioner pins and in two-piece stamped aluminum wheels.

There will be a five to ten percent compound growth rate for titanium in the non-aerospace market during the 1980s. Industrial growth areas include pollution control equipment and the oil and gas industry. These applications result from corrosion resistance, toughness and weldability of titanium alloys.

iii) Superalloys:

A new series of iron-base and nickel-base cast superalloys and wear-resistant alloys are being developed to provide lower cost and freedom from excess use of strategic elements. Applications will be in diesel engines, precombustion cups and valve seat inserts.

iv) Special-Duty Materials:

Applications for nickel-zinc and zinc-chloride battery systems, once commercialized, will be for on-road electric vehicles and utility load leveling.

v) Non-Metallics (Plastics, Ceramics and Composites):

Ceramic materials are being used in many new high-technology applications and are being proposed for numerous components. These may result in a significant influence on the future of electronics, machining operations, automotive and utility power plants, and processing and manufacturing system automation. The bonding and joining of dissimilar materials in these various applications is a critical area of development.

New ceramic materials are being produced that could lead to a more efficient diesel engine and improved artificial bone joints for humans. The application of ceramic thermistors in heat-sensing devices is currently attracting much interest due to industrial efforts in thermal control and process automation. The emerging energy-efficient ceramic engine and turbine blade applications offer the most remarkable future growth prospect. The worldwide automotive market for advanced ceramics is projected to be tens of billions of dollars at maturity. The relatively small market for ceramics in gas and humidity sensors is expected to grow significantly as the need to monitor environments and control processes expands as part of the overall automation process. This pacing technology is emerging now and the opportunity is becoming increasingly apparent.

A number of ceramic applications may not be on the market for seven to twelve years. Due to the significant research base required, however, it is critical for companies to make investments now so they can compete in the market in the future.

vi) Semiconducting Materials:

Silicon is the most important material in use in microcircuit chips. Work is still ongoing to produce even larger diameter single crystals with a more defect-free microstructure. The drive for larger

diameter single crystals is simply to increase productivity, that is, to make existing products cheaper to produce. The technological advance comes through an improvement in the quality of the material. This means fewer structural defects and chemical impurities.

Furthermore, there is the issue of dopant distribution. As the scale of integration increases and the discrete element size decreases, the spatial variation in dopant concentration is crucial and demands tighter tolerances. This is clearly an example of a situation in which an advance in one area supports an advance elsewhere. Computer miniaturization will follow the gains in silicon purity and production efficiency.

It is extremely important to recognize the potential impact of materials substitutions based on technological developments. Advances in materials technology not only represent potential industrial and market opportunities, but could also result in significant disruption to existing industries and markets.

For example, materials advances could make long-distance fibre optics communication a reality. This technology is the essence of a proposed $40 billion development program to be funded by the U.S. defence community. If successful, optical fibre would replace copper in communications networks. The impact on the copper industry would be twofold. First, a large existing market would be lost, and second, the copper industry would have to absorb all of the existing cable, which would have to be physically replaced. The combined economic impact on the copper industry could be devastating.

The example of copper versus optical fibre in communication applications in not unique with respect to the impact of advanced materials developments and substitutions. High-technology ceramics, as discussed in more detail later, have the potential to revolutionize

internal combustion, diesel and turbine engine technology as well as replace many strategic materials, such as tungsten and cobalt, in cutting tool and superalloy applications. Clearly, advances in materials technology have both upside potential for new commerce and downside risk for existing industries. The motivation to provide meaningful policies with respect to technology development is not solely to advance the economy but, more importantly, to avoid major disruptions within the economy due to technology illiteracy.

c) Other Government Support:

i) Japanese Support for High-Technology Ceramics: A Case Study of Strategic Importance:[1]

In view of the confines of this paper, a quantitative review of recent worldwide activities in all advanced materials is impossible. Instead, a focused view of recent developments in advanced or high-technology ceramics is presented. This particular advanced material is chosen because it represents a significant technology leverage point with global technological and economic implications. Technological leadership in the production and fabrication of high-technology ceramic components promises to provide an enhanced competitive position in the international marketplace for electronic equipment, computers, automobiles and trucks, cutting tools and power generation equipment. The current global market for high-technology ceramics is roughly $4.25 billion and is expanding rapidly.

Recent Japanese efforts in this emerging area are presented as a case study of one country's policies concerning high-technology

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[1] Much of the technical detail that follows is taken from "High Tech Ceramics in Japan: Current and Future Markets," by George B. Kenney and H. Kent Bowen, American Ceramic Society Bulletin, Vol. 62, No. 5, May, 1983.

development. Advanced materials are regarded by the Japanese as the basis of their high-technology strategy.

High-technology ceramics are high-value-added materials that deliver superior mechanical, electrical, magnetic and optical properties and performance. Many are based on readily available materials such as oxides, nitrides or carbides of silicon, aluminum, zirconium and iron. The essence of this technology is that common starting materials are converted into high-value-added components by sophisticated high-technology processing and manufacturing systems. For example, high-technology ceramics have been demonstrated to be technically viable as internal engine components. These ceramic engines promise improvements in fuel economy in the range of 40 percent over the metallic engines.

Earlier this year in Japan, Kyoto Ceramics successfully road-tested a diesel engine with ceramics components that runs at 1,204°C, is lighter, and requires no coolant or lubricant and lower maintenance costs than steel engines. Japanese auto makers anticipate full commercialization of ceramic diesel engines during the late 1980s, with ceramic gas turbines to follow in the 1990s. The potential market for ceramic engines could reach $30 billion worldwide by the end of the century. The global economic implications include tens of billions of dollars in foreign trade and hundreds of thousands of jobs created or lost in the automotive industry alone.

An added incentive to develop fine ceramics, the basis of Japan's current 50 percent global market share, is provided by Japan's burgeoning electronics industry. Electronics applications account for approximately 88 percent and 70 percent of the total market value of Japanese and world production of fine ceramics respectively. Japanese firms are currently developing new products, miniaturizing existing components and advancing product quality. The ongoing Japanese national

projects in VLSI, the fifth generation computer, functional device developments and the nuclear industry are all continuing benefactors of the high-technology ceramic program. However, while the electronics market offers significant growth potential, it is dwarfed by the potential size and impact of fine ceramics in heat-resistant applications, which include engine and turbine components.

The current challenge for ceramic industry leadership comes from Japan. In 1981, Japan's Ministry of International Trade and Industry (MITI) launched a 10-year program for the development of basic technologies for the next generation industry, within which ceramics is one of the core programs. Several new industrial trade associations, including the Fine Ceramics Technology Research Association, were established in response to this initiative. It has as its goal the promotion of joint technological development of the fine ceramics industry and its effective and early entry into the market. There are currently 18 Japanese institutions and firms engaged in various MITI-sponsored fine ceramics research projects. All results are shared equally by all participants and advisory committees with the government retaining most patent rights. Japanese economic and industrial planners have clearly placed the emphasis on new materials development.

In addition to MITI, other government agencies have committed substantial funding to promote scientific and technological research in the area of high-technology ceramics. On the industrial side, Kyoto Ceramic recently announced plans to build a central research facility in 1983 that is to be staffed by 200 researchers.

In July of 1982, MITI also established the Fine Ceramics Office, citing fine ceramics as the "new generation of materials to replace metals." Shortly after its creation, 170 companies had joined. The purpose of the Fine Ceramics Office is to assist both the producers and

the consumers of fine ceramics by providing surveys of both the industry and its markets, and specifically assisting the user segment to design new products based on ceramic materials.

In March, 1983, a MITI-supported New Ceramics Fair was held in Nagoya. More than 130,000 people attended. The average citizen of Japan is acutely aware of high-technology ceramics and the future potential of these materials and other technologies.

The national effort on the part of the government, academic institutions and industries of Japan to collaboratively develop and promote high-technology ceramics represents a major initiative to achieve technological and market leadership within this class of engineering materials. The principal motivation for the new national commitment to fine ceramics in Japan was provided by the 1973 and 1979 oil crises. With no significant domestic energy supplies, Japan is currently dependent on petroleum imports for more than 70 percent of its primary energy needs. Prior to the oil shock, Japan's industrial structure and development policies emphasized energy intensive basic materials such as steel, copper, aluminum and coal as well as heavy chemical industries. These industries helped provide the rapid growth of the 1960s.

Faced with the current slowdown in worldwide economic activity and high energy costs, Japan is readjusting its long-term industrial policy toward "softwarization," that is, a combination of knowledge-intensive secondary processing and service-oriented industries. High-value-added primary and secondary processing of high-technology ceramics, for electronic as well as heat- and wear-resistance applications in machine tools and engines, meets these policy specifications. As well, it offers the bonus of potential major contributions to energy efficiency.

The Japanese government and industry, in short, are intent on developing the full spectrum of technology necessary to extend electronics

applications and to commercialize mechanical applications of fine ceramics. If successful, this initiative would further enhance the competitive position of Japan's electronics industry. It would also secure technological leadership in the next generation of energy-efficient oil- and gas-fueled power plants in automotive, industrial and utility applications. Leadership in efficient energy conversion systems based on fine ceramic technology would provide Japanese industry with a subsequent production cost advantage, minimize Japanese dependence on foreign imports of petroleum products and strategic materials, such as cobalt and chromium, and secure extensive foreign markets for Japanese products such as automobiles, internal combustion engines and turbines.

Clearly, fine ceramics offer Japan an opportunity to minimize its critical dependence on raw materials and foreign petroleum, and maintain or expand its economic growth and export market share, on which the health of the Japanese economy is based.

ii) Other Countries' Developments in High-Technology Ceramics:

The rest of the world is not conceding this strategically important technology to Japan. U.S. firms currently hold a slight edge over Japan in open market share for high-technology ceramics. However, this open market does not take into account the production and proprietary use of high-technology ceramics by large vertically integrated component companies. This includes IBM, which recently invested $1 billion in the research, development and manufacture of a sophisticated ceramic substrate for the innovative thermal conduction module. This substrate serves as the foundation for one of its state-of-the-art high capacity computers. In addition, the U.S. government has provided more than $100 million to the Ceramic Gas Turbine Engine Development Program during the past 10 years.

In contrast, Great Britain, a traditional leader in the development of ceramics, has lost its position. However, ceramic turbochargers are scheduled to appear on some European automobiles in 1985/86. In addition, the European Economic Community is expected to announce, in the near future, a collaborative research and development effort to counter the Japanese initiative in high-technology ceramics.

CHAPTER 2

TECHNOLOGY: THE ONTARIO ECONOMY

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CHAPTER 2

TECHNOLOGY: THE ONTARIO ECONOMY

1. INTRODUCTION

The past decade has dealt several harsh economic blows to the Canadian and Ontario economies: two oil price shocks, persistent inflation, a historically unprecedented slump in productivity growth and the most severe economic slowdown in half a century.

Apart from these internationally felt, very visible "threats," there has been an underlying and less noticeable, but constant, erosion of Canada's and Ontario's industrial competitiveness during the past 10 years. This structural weakening of our industries, which has been blamed by some for the declining value of our dollar, the closing of our textile mills and the layoffs of our auto workers, has left the economy in a vulnerable position.

The following illustrates the slippage in Canadian competitiveness, in many cases rooted in Ontario's industrial base. Chart 2-1 illustrates that, despite a continued surplus in Canada's merchandise trade balance, the deficit in manufactured end products continues to deepen. Growing market penetration by our manufacturing competitors is, for the time being, offset by our resource exports. As seen in Chart 2-2, however, this increasing product deficit is most pronounced in medium- and high-technology commodities.

Some understanding of the growing deficit may be gained by examining our recent productivity performance record. As indicated in Chart 2-3, productivity growth in Canada has stagnated both in relation to our past performance and, as shown in Chart 2-4, in relation to the performance of our global competitors. Chart 2-4 further indicates that while productivity growth has slowed in all major OECD countries during

the past decade, nowhere has the slowdown been more severe than in Canada. As disturbing as this overall productivity slump is for competitive prospects, Canada's relative performance in manufacturing productivity should be of special concern to Ontario, as indicated in Chart 2-5. Of the 11 industrial countries surveyed, Canada ranked last in manufacturing productivity growth during the 1973-81 period.

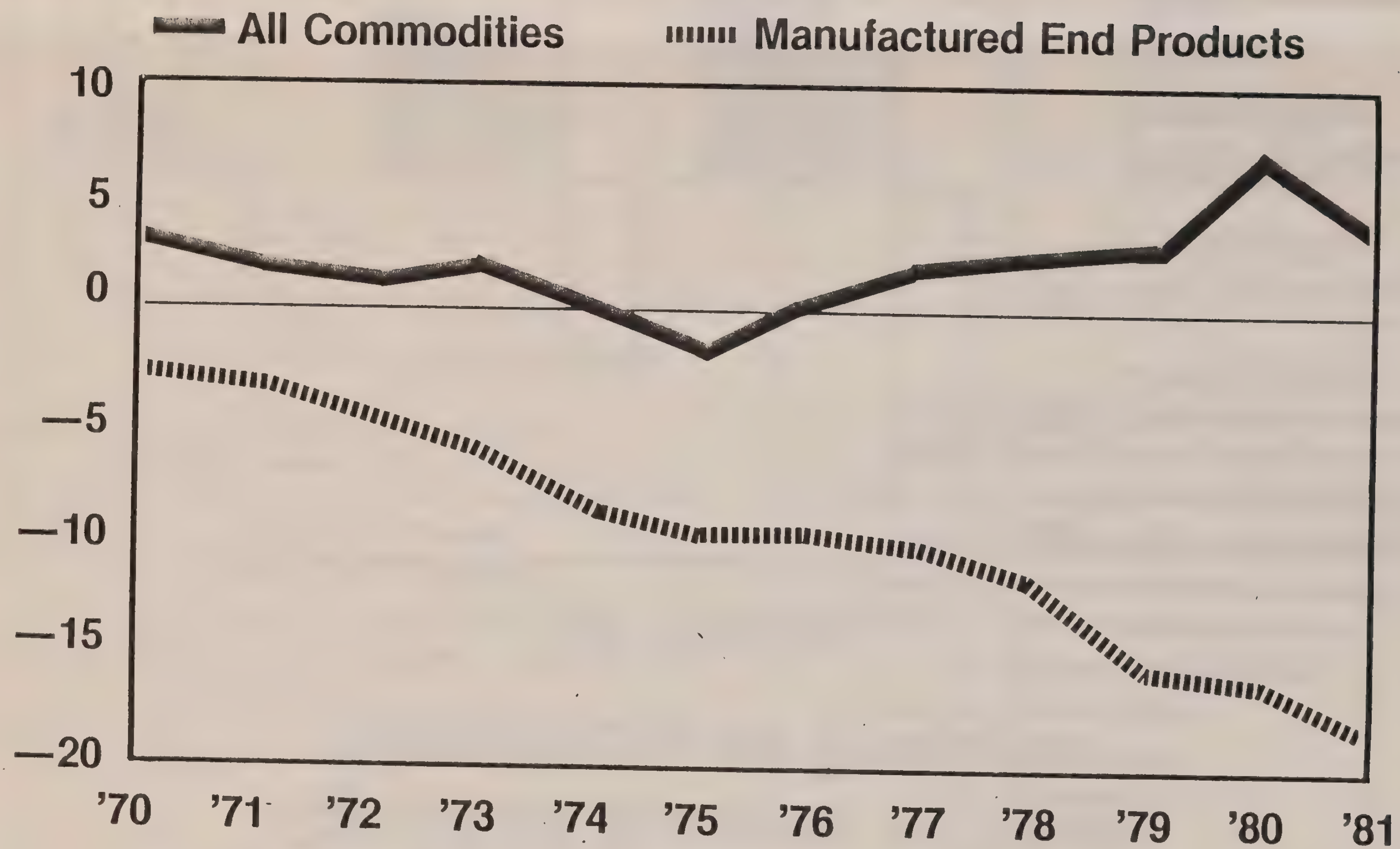
Such dismal results are commonly attributed to a number of factors: lagging capital investment, a poor management/labour record, a lack of commitment to industrial R&D, an inordinately high degree of foreign ownership within the Canadian manufacturing base, among many others.

Whatever the real and lengthy list of causes, there is little doubt that Canada's and Ontario's economic performance during the past decade has left us vulnerable to the competition for our own domestic market as well as for investment, jobs and export market share opportunities.

It has become evident that introducing and effectively managing technology are required for Ontario's competitive renewal. This chapter and Chapter 3 describe how these two keys to competitive renewal are intimately related to our future economic prospects.

Canadian Balance of Trade

($ Billions)

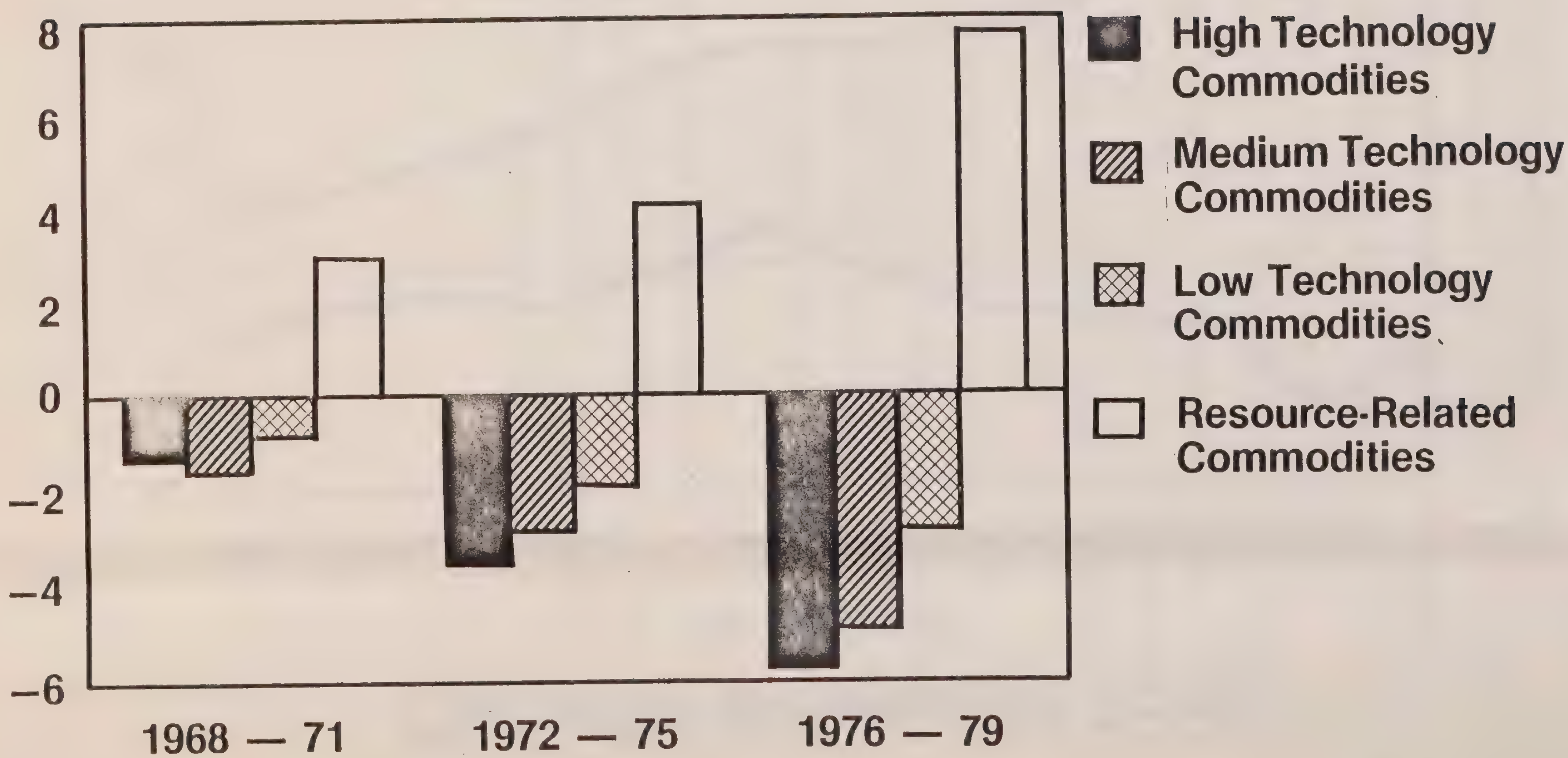


Source: Statistics Canada, 1983

Chart 2—1

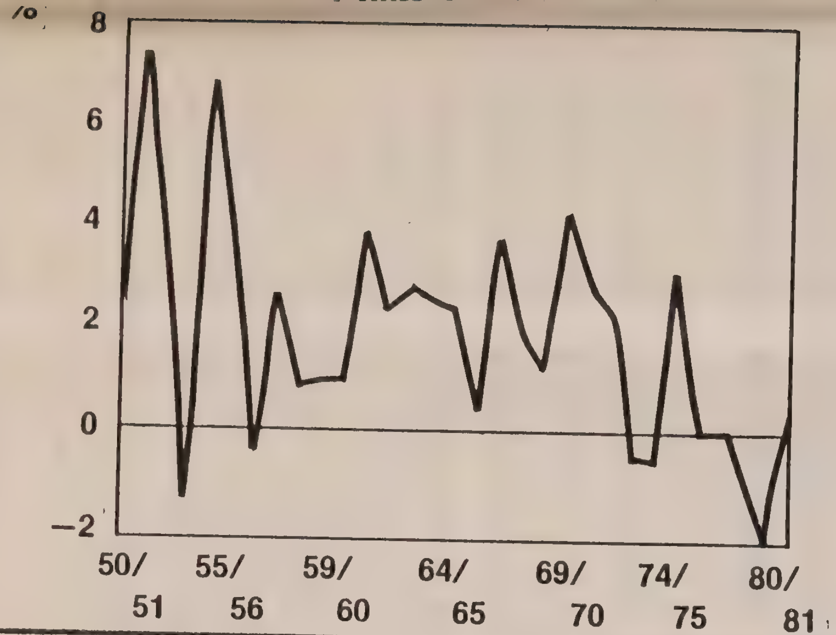
Canadian Balance of Trade, Manufactured Products

($ Billions)



Source: Statistics Canada, 1983

Chart 2—2



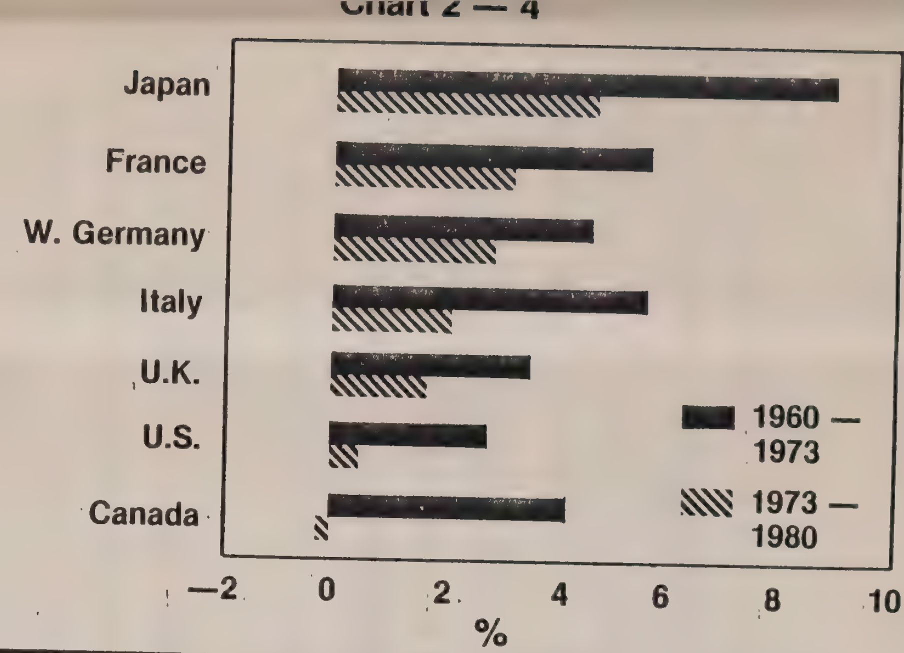


Chart 2 — 5

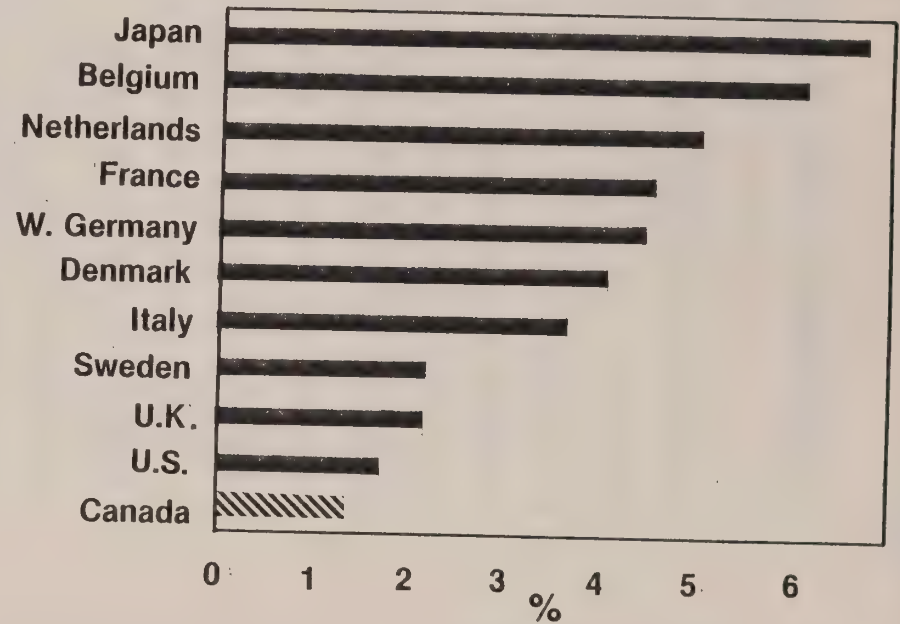


Chart 2 — 3 Canadian Labour Productivity Growth

Source: Economic Council of Canada and Statistics Canada, 1983

Chart 2 — 4 Productivity Growth: Major OECD Countries

Note: Growth in output per person employed
Source: OECD, "Economic Outlook", December 1982

Chart 2 — 5 Manufacturing Productivity Growth, 1973—81

Note: % change in output per person employed
Source: U.S. Dept. of Labour

2. THE PRODUCERS OF HIGH TECHNOLOGY

The world economy of the late 1980s and beyond will be powerfully shaped by the international distribution of technology production. It is essential, in strategic terms, that Ontario have some representation in this area. As indicated in Table 2-1, high-technology producers display higher than average growth performance and have come to play a more crucial role in defining our trade position. As well, high-technology products and processes, through their impact on industrial productivity, promise to boost Ontario's overall trade performance and rate of economic growth.

Ontario producers have already established some leading foothold positions in new technologies. Lasers, fibre optics and computer software development are some examples discussed in Chapter 1. However, Chapter 1 has also made it clear that technical advances and emerging market positions are developing rapidly in several technology areas. Accordingly, it should be a matter of topmost priority that Ontario determine, now, where its prospective footholds are and what measures can help to ensure that these opportunities are seized.

The growing importance of technology-intensive industries to the Ontario economy is already clear. By 1981, the value of goods shipped by the adolescent Canadian electronics industry stood third to the automobile and iron and steel industries, for more than a generation the engines of growth for both the Canadian and Ontario economies. During the 1970s, those Canadian industries extensively engaged in product and process development and those that developed and applied new techniques vigorously increased their capabilities and industrial leadership. Throughout the past decade, they consistently led national industrial gains in employment, output and productivity, while achieving price moderation as indicated in Table 2-1.

TABLE 2-1

TECHNOLOGY-ADVANCING INDUSTRIES LEAD CANADIAN MANUFACTURING PERFORMANCE

(Percentage Increases, 1970-78)

Group Technology

Status[1]	Employment	Real[2] Output	Productivity[3]	Prices[4]
High Intensity	3.7	49.2	43.9	48.4
Medium Intensity	13.8	41.3	24.1	74.1
Low Intensity	11.9	42.5	27.3	62.3
No Intensity	4.2	21.4	16.5	70.4
Total Manufacturing	9.4	37.5	25.0	62.6

Source: Statistics Canada, various years

The increasingly pivotal position of higher-technology commodities in our overall trade in manufactured products is illustrated in Chart 2-2.

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1 Technology Intensity: based on intramural product research and development expenditures, as percentage of industry output.

- high intensity: chemicals, electrical, aircraft and parts, scientific and professional equipment, machinery
- medium intensity: paper and allied, primary metal, other transportation, petroleum products
- low intensity: food and beverages, tobacco, rubber and plastics, textiles, wood, furniture, metal fabricating, non-metallic minerals
- no intensity: leather, knitting mills, clothing, printing, publishing and allied, other miscellaneous and manufacturing

2 1971 dollars

3 Real output per person

4 Value-added implicit price index, 1971-77

3. USING HIGH TECHNOLOGY: A KEY TO COMPETITIVE RENEWAL

Some of the most intractable problems of competitive adjustment in Ontario have occurred in some of our mature manufacturing industries. In these types of industries, the technical problems concerning what a product should be and how it should be made have been more or less settled. Consequently, it frequently happens that product and process technologies become standardized, stable and easy to copy. A manufacturing industry in this position is in danger of becoming vulnerable on two counts: to low-cost import competition, with textiles being the classic example; and to a drift of production offshore. A good example of the latter is television sets, which have not been fully manufactured in Ontario for 12 years. Ontario has no presence in the subsequent generation of technology, videotape recorders, where Japanese producers dominate the world market.

The assumption is too often made that, in the course of an industry's development, the inevitable step beyond maturity is to industrial decline. The competitively significant fact is that managers in many of our mature industries have evidently accepted this view. All too often their response has been to emigrate offshore or face the prospect of extinction once their costs get seriously out of line with their global competitors, or to use their mature product division as a "cash cow" to finance diversification into a more promising line of business.

Both of these responses can lead to the all too familiar public policy dilemma of whether to support a declining industry through such measures as trade protection and infusions of public funds or to allow that industry to be phased out.

Ontario is involved in an increasingly global marketplace and, without doubt, jobs will continue to be lost in some industries to foreign

producers and locations. However, just as surely, many other cases will arise where advanced manufacturing technologies can ease the dilemmas of adjustment, if not avoid them altogether. Indeed, a new factor in the competitive equation for Ontario is that technology can provide entirely novel opportunities for the regeneration of mature industries.

The introduction and effective management of computer-integrated manufacturing can call into question some of the alleged competitive facts of life facing our mature manufacturing industries. One of these facts is that a mature industry cannot regenerate itself by returning to a condition where basic questions concerning the most effective process and product technologies are unresolved. This is akin to the situation in younger industries and, where such technological uncertainties prevail, technical innovation (process and product) carries a competitive premium.

The point is that writing off our mature industries is premature. Many of them can rejuvenate themselves and compete if they invest in various types of flexible automation systems and harness their competitive potential by learning to manage them well. This opens opportunities for a company in a mature industry to sharpen its competitive weapons. The impact of technology on Ontario industries such as automobiles, medical devices, clothing and footwear is discussed later in this chapter.

A. Flexible Automation and Productivity

The contributions of new industrial technologies, although not a panacea, undoubtedly hold part of the answer to lagging productivity performance and to competitive adjustment challenges. Numerically controlled (NC) machines, flexible machining cells, CAD/CAM equipment and robots, in addition to office automation, simultaneously raise performance

and product quality, are cost-effective and can be applied, in some combination, in most factories and offices.

The introduction of new technology on the plant floor offers the manufacturer a systemic, not a new "point" capability, which allows greater efficiency at an increasing number of phases throughout the production process. The initial advent of an NC machine, a machining centre, or an automated monitoring and instrumentation device on the plant floor can lead the operation on an increasingly developmental path. It can lead to computer-assisted manufacturing, to the use of robots of varying degrees of sophistication (from manual manipulative, through fixed sequence, to playback, to intelligent) and, ultimately, to a totally integrated and flexible automated production process.

Computer-driven process technology offers progressively greater benefits as it integrates more sectors of a plant's operations. Value added comes from linking machines with one another, with their materials flows and with performance evaluation, financial control and planning systems. It is also derived from reduced downtime, smaller parts inventories and decreased maintenance, all characteristic improvements in the new machines beyond their execution functions.

The productivity improvements brought by the new technology are evident. They include the potential for a continuous operation, efficiency in material use and work in progress, quality monitoring of supplies and product, industrial safety, market responsiveness through flexibility in scale, scope, product development and the substitution of reprogramming for retooling.

The economics of flexible automation are becoming increasingly attractive. Prices of some types of programmable factory equipment are expected to remain steady or even decline somewhat during the next few years. This is because microchips, the driving force behind the

equipment, are becoming more powerful and reliable and less expensive. Declining equipment costs relative to labour, along with substantially higher equipment productivity, are leading to shorter payback periods. That one of our most formidable global competitors is benefiting from these shifting economies is illustrated in Table 2-2.

TABLE 2-2

FLEXIBLE AUTOMATION PAYBACK PERIODS DECLINE IN JAPAN

	Year	Per Unit Price of Equipment/ Annual Per Capita Labour Cost
Playback Robot	1974	10.0:1
	1976	8.1:1
	1978	6.2:1
	1980	4.5:1
	1982	2.5:1
Numerically Controlled Machining Centre	1974	14.6:1
	1976	10.4:1
	1978	7.2:1
	1980	5.9:1

Note: The robot price was calculated assuming that the robot required peripheral equipment and accessories equal in price to the robot itself.

Sources: MITI: Japan Industrial Robot Association: Daiwa Securities, 1982.

As flexible automation emerges in North American manufacturing, similar benefits are being realized in Ontario. For example, Canadian Tire (Brampton) reports an 18-month payback period on its $6 million computer-aided warehousing system.

As an illustration of the order-of-magnitude improvements possible in plant productivity, Tables 2-3 and 2-4 display the documented performance of Japanese and Swedish firms that have developed flexible manufacturing systems.

TABLE 2-3

FLEXIBLE AUTOMATION PERFORMANCE
IN JAPAN

	"Hard" Automation	"Flexible" Automation	Productivity Effect
Toshiba Tungaloy			
(cutting tool plant)			
No. of machine tools	50	6	88% decline
Operating rate/downtime	20%	70%	350% increase
Floor space (sq. metres)	1480	350	76% decline
Work time/output (days)	18.6	4.2	77% decline
Niigata Engineering			
(section of diesel engine plant)			
No. of machine tools	31	5	84% decline
Work time/output (days)	16	4	75% decline

Source: Daiwa Securities. Research Report on Flexible Manufacturing Systems, 1982

TABLE 2-4

FLEXIBLE AUTOMATION PERFORMANCE
IN SWEDEN

Household Appliance Parts Manufacture	"Hard" Automation	"Flexible" Automation	Productivity Effect
No. of operators	28	6	79% decline
Floor space (m^2)	1700	300	82% decline
Investment cost	.709	1.340	
(millions of $Cdn)			
Payback period		1.5 yrs	

Source: Computers and Electronics Commission. Stockholm, 1982

The Ontario example in Table 2-5 indicates that the same productivity potential can be realized here. It is noteworthy that all of the output to fulfill a $16 million contract in the example is to be exported.

TABLE 2-5

FLEXIBLE AUTOMATION PERFORMANCE IN ONTARIO

	1979 Machines	1983 Machine System
Price of equipment	c. $2MM	c. $2MM
Labour requirement	9/shift	1/shift
Machining time/unit	300 min	71 min
Downtime	required on third shift	none

Source: Linamar Ltd., Ariss, Ontario, 1983

B. The Use of Flexible Automation by Our Global Competitors

Japan is overwhelmingly ahead of all other countries in the acceptance and use of flexible automation and, with an acknowledged long-term goal of unmanned factories, continues to integrate CAD/CAM and robotics technologies into manufacturing processes. Adjusting for definitional differences, in 1982 approximately 55 percent of the world's industrial robots were in use in Japan.

Flexible automation embraces more than the use of industrial robots, and frequently relies on systems effects with other computer-driven tools to achieve its remarkable productivity results. Nevertheless, a useful international perspective is provided by Table 2-6 on the intensity of robot use in the manufacturing sectors of selected countries.

TABLE 2-6

ROBOTS PER 10,000 EMPLOYED IN MANUFACTURING

	1974	1978	1980	1981
Sweden	1.3	13.2	18.7	29.9
Japan	1.9	4.2	8.3	13.0
West Germany	0.4	0.9	2.3	4.6
United States	0.8	2.1	3.1	4.0
United Kingdom	0.1	0.2	0.6	1.2
France	0.1	0.2	0.4	1.2
Canada			0.5	0.8

Source: OECD, "Indicators of Industrial Activity." 1982. Canadian data estimated by the Ministry of Science and Technology, 1983.

4. THE IMPACT OF TECHNOLOGY ON SELECTED ONTARIO INDUSTRIES

The impact of technology on Ontario's economy can be illustrated by reference to selected industries. This section discusses four industries in Ontario with case examples of how two industries are adopting new technology to meet their competition.

- The automotive industry and its suppliers together form a centrepiece for Ontario's manufacturing base. They serve as both a highly visible example of competitive renewal through advanced manufacturing technologies and a key support for production of high-technology goods in the province.
- The medical devices industry illustrates some of the most fruitful applications of microelectronic, computer and laser technologies. It promises to make yet more impressive growth contributions to one of the most research-intensive sectors of Ontario's economy.
- The clothing and textiles industry, long the classic example of a mature industry subject to severe cost competition from offshore, has begun the kind of technological upgrading and retraining that can anchor jobs in Ontario.
- The footwear industry, also historically subject to strong international competition, provides an example of the effective use of CAD and numerically controlled machines to cut costs while also giving a marketing edge.

A. Automotive Industry

The automotive industry, perhaps more than any other, illustrates the linkages between technology and the prospects for Ontario's economic competitiveness. It does this, first, as the most

prominent example of a once mature manufacturing industry now in the process of regenerating itself through advanced production technologies and managerial innovations: and, second, as a large developer of and customer for several high-technology goods.

a) Technology and Competition:

By the mid-1970s the domestic auto industry had been in a period of technological maturity for several years. The prevailing forms of competition in the industry placed a greater stress on styling and marketing initiatives, with a lesser emphasis on incremental technical improvements in products and processes.

By the late 1970s, this situation had changed in three basic ways: for various reasons, customers began re-examining what they wanted a car to be in terms of fuel economy, quality, reliability and other factors: the industry was presented with some strikingly new ways in which automobiles could be manufactured (for example, through the use of CAD systems, industrial robots and new materials): and the industry's external environment, in the form of intense competition from Japan and a prolonged economic recession, made it both more urgent and more difficult for the industry to contend successfully with the formidable challenges facing it.

The auto companies and their suppliers are passing through a difficult and complex transition period whose competitive outcomes are still uncertain. However, it would appear that new technologies and associated management innovations are playing a central role in the efforts of the industry to respond. The results are already evidenced by lower unit costs and break-even points as well as higher quality and shorter product development times.

In Ontario, the auto and auto parts producers have been at the forefront in adopting computer-driven automation and managerial innovations.

At Ford, CAD equipment is being used in the design of all body electrical systems, 50 percent of new body components and 25 percent of other components. At Chrysler, the design of 85 percent of all body components, 60 percent of suspension components and 40 percent of engine components is assisted by computer.

In 1982, nearly two-thirds of the industrial robots in Canada were being used in the automotive industry. GM Canada is currently using 130 industrial robots and is expected to increase their number to 300 by 1985 and to 1,200 by 1990. Likewise, Chrysler's T115 van-wagon assembly plant opened in Windsor in the fall of 1983 equipped with 125 robots.

In the following chapter, several managerial and organizational innovations related to technology are discussed. Those figuring prominently in the revitalization of the auto industry include "just-in-time" inventory management, statistical process control, quality control circles and various employee involvement and suggestion systems.

b) High-Technology Goods Production:

The auto and auto parts industries constitute a key support for high-technology goods production, both through their own research and development efforts and as large customers for such products. These products are becoming increasingly extensive and include on-board computers; electronic engine controls; trip planning and monitoring computers; high-strength lightweight metals; ceramics for engines and parts; several plastics applications; carbon fibres; and flexible automation equipment.

The discussion in Chapter 1 highlights several high-technology goods production opportunities for Ontario. The following examples illustrate how these opportunities are being reinforced by activity within the automotive industry:

- The emerging energy-efficient ceramic engine and turbine blade applications have very rapid growth prospects. The worldwide automotive market for advanced ceramics is projected to reach into the tens of billions of dollars at maturity.
- Many automotive parts will be made from carbon steel instead of alloy steels. As well, the use of galvanized steel in the automotive industry for improved protection against perforation and structural damage by corrosion is expected to rise by 33 percent to 83 percent a year, depending on the type of coatings specified.

B. Medical Devices Industry

It is increasingly apparent that the application of microelectronics and computer technologies will be uniquely invaluable to the medical devices industry. In turn, significant advances in health and medical technologies in the next decade will enhance our abilities to identify - and to treat and prevent - disease. Increases in the power, speed and accuracy of the computer for scanning, analysis and diagnosis, as well as the smaller size, lighter weight and increased reliability of a chip have opened up tremendous opportunities for applications. As discussed in Chapter 1, lasers are a versatile and sophisticated tool and their applications in surgery are increasing. It has been estimated that the worldwide market in medical lasers will double by 1988. Further advances in technologies are expected, in turn, to open up new application areas.

New diagnostic techniques that combine the microprocessor, miniaturization and other existing technologies are rapidly emerging. For example, in X rays, algorithms are being developed to determine the

mineral content in bone for early diagnosis of bone disease. It is apparent that radiology is changing from a film-based to a computer-based technology, and some experts have predicted that X-ray film will be obsolete within 20 years.

The possibility of "seeing" through the stomach wall to the surrounding organs prompted the development of an ultrasonic endoscope - made possible by a marriage of technologies. A miniature transducer array in the endoscope's tip, coupled with a new concept in ultrasonic processing, permits higher resolution imaging of internal organs than is possible with external scanners. This technique paves the way for the development of a whole new family of "seeing" instruments.

Nuclear magnetic imaging, which reflects an organ's physiologic state rather than anatomic structure, is proving particularly useful in imaging the breast and lung. Imaging is also useful for cerebral perfusion and brain scanning. Such new techniques as positron-emission tomography, microwave, and nuclear magnetic resonance hold promise for future medical applications in imaging and in the quantitative assessment of physiologic functions.

Another exciting research area is organic electronics. In effect, it may be possible to grow the equivalent of electronic semiconductors in protein substrates. These organic "chips" would be many times smaller than silicon or gallium arsenide semiconductors. Theoretically, they would interface directly with the human body's biological systems, by measuring the electronic potential of nerves - or even individual cells - through tiny sensors implanted under the skin.

Such organic electronic systems could be used for medical diagnosis or as alarm systems that would react to subtle changes in the body's chemistry or function. They could, for example, trigger the release of drugs in case of an impending heart attack or insulin shock.

The medical devices industry, because of the emphasis on health in a modern industrialized nation, serves as an example of an industry where technology is having a major impact. The potential range of applications raises the question of how a country takes commercial advantage of the research being undertaken by institutes and universities. For example, although the original computerized axial tomography (CAT) scanner was developed in the U.K., it was finally commercialized in the United States through venture capital on a project by project basis.

In Canada, in view of government-financed health systems, the issue is whether the private sector will invest in taking research activity to the commercial stage, or whether the government has a role to play in technology transfer by encouraging research to be taken to this stage.

C. Clothing and Textile Industry

Case Example #1

ADIDAS TEXTILES
Toronto, Ontario

The Canadian and Ontario industrial sector perhaps most pressed by recent international competition is textiles. The large integrated operations in Asia, where minimum runs on shirt orders are 6,000 units compared to the average of 500 in Canada, have led to tremendous employment displacement, loss of capacity, evaporation of firms and a highly protectionist policy in Canada.

Notwithstanding these sectoral problems, Adidas Textiles has undergone capacity expansion and created new jobs, and continues to seek productivity gains through new equipment, procedures and training. Confidence in meeting the competition, according to Werner Syndikus,

senior vice-president, is built into Adidas' productivity plans: "If all import restrictions were dropped tomorrow we would stay - we've got to be here on a sound business decision."

Adidas' strategy since taking over the Toronto plant has been to seek "phase one" productivity through new and increased management infrastructure, improved quality standards, better training and incremental improvements in equipment and production process on the plant floor. The plant's natural progression through capital updating, upgrading and replacement to date is described by John Samuels, general manager, as "going a little bit upstream and a little bit downstream to control more of the business functions." Adidas strategically conceives these efforts as necessary preparation or groundwork for a viable, well-managed plant. This in itself is a prerequisite for effectively introducing "phase two" of more hard automation, software-driven.

The technique that Adidas' management has brought to the operation is summarized in Table 2-7.

TABLE 2-7

DE-MATURING TEXTILES

Conventional	Adidas Textiles	Advantages
1. Design		
. hand scaling, grading	. pattern grader (Texigraph)	. 2%-3% cloth savings . fully automated pattern grader would save another 2%, but costs justified only by largest operations (offshore)
2. Cutting		
. manual loading and spreading	. automatic loader and semi-automatic spreading machine	. extra ply (over 200) = reduced cutting time . reduced labour costs . increased material usage (accuracy)
Remarks: . difficult in this scale to improve via automation on the 76/24 material usage through present skilled marker planning		
3. Transporting		
. hand-carted to sequential production stages	a. interfloor conveyor/delivery system	. "live storage"= reduced handling . increased batch control of work scheduling
. each operator manually picks up work lot for station	b. controlled conveyor line feed to workstations . multi-station serving	. monitor operator performance without confrontation . no walking . "communal watering hole" disappears
Remarks: . payback under 1 year . standard performance efficiency from 72% to 97%		
4. Sewing		
. manual forming and sewing	. automatic pocket setter . forming and multi-directional sewing . mechanical, not electronic	. labour de-skilling . 6 mins/pocket reduced to 25 seconds . increased consistency . disadvantages: harder to accommodate fashion change (re-tooling of head and jig required) . only 7 others in Canadian industry when purchased (many now)

TABLE 2-7 (cont.)

DE-MATURING TEXTILES

Remarks:
- currently planning a multi-needle tape machine, with sensor to active cutter that will replace 2.7 trimming jobs
- "hands-off" sewing requires huge volumes, higher than Canadian runs and company sizes; also, increased fabric changes still need human hand involvement

5. Management

Conventional	Adidas Textiles	Advantages
. usually 2 manager/owners for 100 employees . no succession . often the only assets of the company (labour and equipment "offstreet")	. trained management team	. increased production planning . specialized marketing . reduced labour costs
	. developed supervisor training course; input to CAAT course work	. solid training
	. apprentices	
	. developed Quality Standard Manual, for suppliers	. better, and uniform quality
	. in-house mechanics shop	. prerequisite for further production innovations
	. planning A.Q.L. (average quality level) system in house, based on European learning	. gatekeeping/intelligence undertaken

Adidas has put in place a solid, competitive manufacturing operation that is now ready to effectively address state-of-the-art technology. John Samuels advocates this natural progression in planning new technique: "What we have here today is the basic level. But by comparative Canadian standards, you will look a long way before finding our combination of training, transporting and production system in this industry."

D. Footwear Industry

Case Example #2

BATA ENGINEERING/BATA SHOES
Batawa, Ontario

Bata Engineering, a precision machine shop with more than 400 employees, runs one of the largest NC/CNC manufacturing facilities in Canada. According to Brian Riden, vice-president and general manager, the Batawa machine shop is the best equipped R&D, manufacturing, engineering facility anywhere in the worldwide Bata organization. The impetus for its development, the design and manufacture of automated footwear machines marketed to both Bata plants and its competitors, provided the technical equipment capability for Bata Engineering to produce precision machine assemblies for high-technology customers. These include the defense and aerospace industries. Close to 80 percent of non-footwear output is exported to the United States.

Commenting on the technological requirements for keeping competitive in the precision machining business, Brian Riden states: "If you do not have multi-axis NC machines, you can not quote on the jobs."

The CAD footwear design system currently under development is intended for international marketing. The advantages of the new system are illustrated in Table 2-8.

TABLE 2-8

BATA'S CAD/CAM... FROM FOOTWEAR DESIGN TO ROBOT PART-MACHINING

Technology Facilities

1. NC/CNC machine facility: CAM

- over 2 dozen NC/CNC machines
- machining and milling centres
- lathes and spindle chuckers
- 2 to 5 axis, point to point and continuous path
- quality assurances through machine specs/performance

Application

(a) shoe-making machinery
- direct injection molding machines manufactured
- design and manufacture of molds (soles)

(b) precision-machined parts, e.g. engine blocks, custom hydraulic cylinders, defence items

2. CAD shoe design facility... the marketing edge

Conventional steps	CADs singular	Advantages
1. hand building of shoe last 2. design for last and modifications for grading 3. pattern-making 4. prototype 5. costing 6. customer presentation . all above steps undertaken as different functions in various managed areas of company	. design free of last or grading considerations . customer input can occur pre-prototype . automated cutting . (laser/waterjets) for prototypes . up-front costing and material requirements . design freed from product information specs. = direct to manufacturing sequence	. time in pre-production process, from initiation of design to manufacturing data reduced from 2-3 days to 2-3 hours . market entry timing, allowing pre-production market intelligence . accuracy in style, shape, size and cost of a non-geometric, asymmetric shape (shoe) . singular design focus vs. designers' manual occupation with other functions or steps (e.g. from 1-1.5 to 3-4 designs/day)

CHAPTER 3

TECHNOLOGY: THE MANAGEMENT CHALLENGE

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CHAPTER 3

TECHNOLOGY: THE MANAGEMENT CHALLENGE

1. INTRODUCTION

The previous chapter dealt with the "hardware" side of technology - the production capabilities that new computer-driven equipment affords in plants and offices and the promise that its application holds for regaining competitiveness. While the introduction of new technology creates the potential for competitive renewal, effective management of it is needed in order to realize that potential.

One of Ontario's most vital competitive resources is the pool of managers charged with the introduction and oversight of technology. With the technical capacity of equipment pushing into new frontiers, companies hoping to benefit from it face a daunting set of challenges in fully harnessing its potential. These challenges arise throughout the organization, from the shop floor to the executive suite. Although a body of experience is beginning to emerge among a few companies, this learning situation is unprecedented and many will find themselves attempting to navigate largely uncharted territory.

Management's job in applying new technology is maximizing its input to the production process while minimizing potentially adverse effects on the production organization. Yet many managers are fearful and hesitant in their reactions to new industrial and office technologies.

Managers have had to deal with the current recession, as well as adapting to concurrent transitional pressures in business organizations during the past several years. In addition, present blame for productivity decline and technology lag has shifted from both labour and government to land squarely on industrial and business management, often

with self-admonition. It has been stated that "the group responsible for the current decline in production is not the worker. but management."[1]

If management is to shoulder such blame for productivity declines, the question arises as to where it has gone wrong. An intensive two-year study of senior managers from 200 North American companies, representing 37 industrial sectors, provides interesting results.[2] It analyzed executive opinion on the causes of success or disappointment in management efforts to improve productivity, and reported the results shown in Table 3-1.

TABLE 3-1

PRODUCTIVITY IMPROVEMENT EFFORTS

Reason for Success	Percent Selected
° capital investment in plant equipment and process	72
° top management commitment and involvement	61
° good financial control and information system	45
° good employee relations	38
° good communications	35
° coordination and cooperation among organizational functions and departments	27
° a comprehensive, systematic, company-wide approach to productivity improvement	22
° incentives and rewards	14
° cooperative union leadership	6

However, the majority of management productivity schemes commence with measures geared to, and relying on, the two least-cited success factors: pay hikes and union concessions.

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1 Productivity Research Group of Canada (consisting of banks, trust companies, insurance companies and manufacturing), 1983.

2 Gray-Judson Survey, Boston, 1982.

The study also found that a full 25 percent of executives do not even know the measure of their company's productivity performance. The main causes of disappointing results were listed as programs with short time horizons geared to quick solutions (75 percent of all programs had a schedule of less than one year), initiatives addressing minor problems (e.g. correcting the abuse of lunch periods), efforts of too narrow scope (e.g. the effectiveness of direct labour functions in production) and minimal top management involvement. Not one senior manager cited unfair foreign competition for declining corporate productivity, only three percent cited labour unions, and just seven percent cited an adversary relationship with government.

One of the themes emerging from the survey is that the efficient application of new production technologies depends for its success on the positive elements cited in Table 3-1. Regenerating corporate productivity demands a move away from adversarial relations based on worker distrust, management isolation and perceived labour incompetence. It is becoming clear that new technology's promise for increased productivity needs to be harnessed by managerial behavior that is counter to many traditional approaches. In short, technology-driven production capabilities need to be managed differently and require some basic departures from traditional management responses.

2. MANAGEMENT REQUIREMENTS OF THE NEW TECHNOLOGY

A recent panel of factory automation experts was almost unanimous in concluding that "the most difficult problems in implementing CAM systems are managerial, not technical."[1]

Chart 3-1 illustrates some of the key production and management opportunities or prerequisites. The displayed capabilities can exemplify a word processing/microcomputer work station in an office or a robotic machining centre on the plant floor. The plant manager and the office executive must confront the new technology management requirements illustrated in Chart 3-1 in order to achieve productivity results. These results are all too often automatically expected upon a machine's installation.

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1 (Ninety-two percent of the 64 surveyed agreed with this assessment.) Factory Automation Research Project, Manufacturing Roundtable Group, Boston University, 1983.

CHART 3-1

NEW MANAGEMENT REQUIREMENTS

HIGH TECH'S CAPABILITIES...	for PRODUCTION...	bring RESULTS...	if MANAGEMENT REQUIREMENTS are met
1. mechanical and physical capabilities: **execution**	. speed . durability . safety . utilization	. increase output . increased QWL, as routine tasks disappear	. responsibility for directing machine replaces efficiency of hands . work rules simplified . cross-trained employees to control various elements of execution
2. fidelity and accuracy, in compliance with instruction: **performance**	. stability . predictability	. increased product quality . increase production precision	. process control instructed throughout, replacing inspection/standards . production planning/logistics for all phases becomes exacting . shared data bases, information required
3. ready change of production behavior: **market-exploitive**	. design modif/ changeover . batch	. <u>product</u> innovation and development	. horizontal communications needed . managers must know operations . group technology/small group activities most effective
4. integrated system: **expansionary**	. internal innovation . real time information reporting	. <u>process</u> innovation development, quickly . capabilities expand for 1-3, in iterative fashion	. integration of functions to allow and guide uncharted expansion capabilities . both long-term and daily planning are essential

Source: John Perry, Development Consulting Limited, 1983.

The management requirements listed in Chart 3-1 demand a major shift away from traditional management approaches stressing execution and toward further development of performance, through productivity and quality, as illustrated in Chart 3-2.

CHART 3-2

MANAGEMENT PRODUCTIVITY FOCUS

EXECUTING PRODUCTIVELY (traditional)	DEVELOPING PRODUCTIVE POTENTIAL (utilizing new technology's capabilities)
1. a judgment call on performance, related to standards devised by management	1. a production measurement, covering and relying on all functions in the process
2. improved and approved by inspection, direction and regulation	2. built into the production process by workers and management, across all work areas
3. 85% the responsibility of supervisors and engineering, 15% plant workers, top down	3. responsibility of all, bottom up
4. a short-term cost challenge in engineering and inspection in a closed system, geared to volume, based on historical plan targets: **execution**	4. an ongoing process of experimentation and applications in an open system maximizing performance, quality and continual process improvement: **innovation**

Source: John Perry, Development Consulting Limited, 1983.

The two functions of execution and the design and planning of tasks for execution exist in all businesses today. However, the time allocated to each of them is being significantly altered by technological installation. Given the unmatchable execution powers of automated equipment and the attendant time relief from performance supervision, the share of design and planning time in companies is now being substantively

increased at both the management and worker levels. The manager's former top priority of directing human execution is suddenly relieved. Moreover, the efficiency of adapting even more tasks to be machine-executed provides greater stress on management to think faster, farther ahead and more often. Many traditional routine management tasks require progressively less attention.

The shifting of management responsibilities may also require new ways of thinking about traditional sources of competitive advantage and about appropriate targets for cost reduction. The experience of our Japanese competitors may be instructive here.

In operational terms, inventory is commonly treated in Japan as a debit rather than an asset - a reservoir where higher costs and production problems can hide. It is abundantly clear that just-in-time inventory management can not only reduce carrying costs, but can also instill higher productivity and product quality. As inventory levels are reduced, the immediate consequences of interruptions in production are intensified. As a result, managers and workers face intensified pressure to work more closely as a team and to mobilize their efforts quickly and efficiently to solve problems as they arise.

On the other hand, labour in Japan is treated as an asset, with dynamic capabilities that can be developed, nurtured and shaped into formidable competitive weapons. The premium that the new technology places on further developing workers' productive potential, while constituting a challenge, also presents an opportunity to strengthen the competitiveness of an organization. The system of work force management in Japan has been credited, time and again, as a key basis of that country's competitive success. The special skills and broad educational strengths of Ontario's work force hold similar potential. The case examples that conclude this chapter offer some telling illustrations of how this potential is being tapped.

3. TECHNOLOGY-DRIVEN MANAGERS AND WORKERS

The competitive enhancement gained by maximizing technology's capabilities in a plant or office, and the need to respond efficiently in order to harness its potential, are now helping to shape new managers, new workers and their meeting grounds - new organizations. Their jobs, which may well begin to be defined through application of the management requirements cited in Charts 3-1 and 3-2, are outlined in Chart 3-3.

In a plant or office, once automation deals efficiently with execution, quality and monitoring, both management and labour are free to focus on planning, design and innovation potential. The traditional desires to share in performance results can now be backed by shared responsibility for results and shared planning to produce them.

The potential clearly exists for this situation to provide the logical basis for white collar/blue collar adversaries to become industrial allies. However, the competitive challenge of adapting to new technology cannot, alone, induce each side to change its attitude toward the other. Gains in trust and joint experience will have to be solidly supported by unheralded training efforts to allow, in the beginning, each individual - manager or employee - the comfort of continued personal competence throughout these job priority shifts.

CHART 3-3

NEW JOB DESCRIPTIONS

NEW MANAGERS		NEW WORKERS	
Reduced Priority	**Enhanced Priority**	**Enhanced Priority**	**Reduced Priority**
1. directing execution	° planning execution	° directing execution	° executing
2. devising performance standards	° participating in raising performance measurements	° contributing to raising performance measurements	° meeting performance standards
3. meeting production targets, volume-based	° designing new efficiencies, quality-based	° directing new quality	° providing volume
4. process refining, to down costs	° process innovative, to link to market	° process initiative, to share market gains	° process adaptive, for increased volume
5. administrative, financial reporting	° operational production knowledge, process control	° production control, design knowledge	° task assignment, component knowledge
6. command chains: vertical information, assignment and delegation	° problem solving; shared information	° taking on responsibility	° responding to instruction
7. individual competition	° team competition	° membership in productive unit	° individual task
8. efficient mastery of routine tasks	° "design" thought applied to new output potential	° range of tasks and functions	° repetitive routine
9. drive down labour costs	° make labour responsible	° share in production decisions performance results	° wring results from management
WHITE COLLAR	**RAINBOW COLLAR WORKERS**		**BLUE COLLAR**

Source: John Perry, Development Consulting Limited, 1983.

4. METHODOLOGIES FOR MANAGING NEW TECHNOLOGIES

The competitive potentials of the new production capabilities are being harnessed most effectively by management methods that require shared responsibility. These include team problem solving, analytical evaluation and precision quality results. Traditionally. such cooperation combined with "working-smarter" has only been mustered under strategic duress; for example, NASA's management system during the Kennedy era or the training of the East German women's olympic team.

The application of these techniques across a broad industrial/ service base was not considered until the Japanese determined that their industries would become a major strategic asset. They combined the German consensual management techniques of codetermination with the American managerial bottom line of results, and set out to capture market share in mature industries where Western competitors were complacent. These industries included textiles, shipbuilding, steel, radios and televisions. The Japanese moved from basic industries up the consumer goods ladder, using market share success to augment price advantages and to bankroll further advantages in technology, product quality and price.

To what degree the management methods applied so successfully in Japan can be replicated by North American industries is a topic currently under debate. There are at least two reasons for believing that some of these methods can be transferred for successful application here.

Many of the basic ideas and techniques underlying Japanese management successes, such as quality control circles, were originally derived from North America. Further, the emergence of Japanese business experience with North American work forces in plants and offices is demonstrating that many of these practices are rewarded with impressive competitive success in our own business system.

Chart 3-4 (page 109) provides a listing of specific examples of where management methodologies, so far proven very powerful in harnessing technology's promise on the plant floor and in the office, have been implemented in Ontario.

Quality control (QC) circles generally consist of small groups of employees, engaged in day-to-day operations at the plant level, that help identify production problems, devise plans for solving the problems and help to put the solutions into practice. TRW Canada (St. Catharines), as one example, has had QC circles since the spring of 1982. The following results, among others, have been realized through the initiative of the circles: reconfiguration of plant layout, more efficient location of die repair operations and greater durability of the electro-discharge machine system. Following these initial successes, TRW has extended the QC circle program to its data processing operations.

Venture teams, a feature of 3M in Minneapolis, have played a key role in spurring innovation within companies. Once an innovation opportunity is identified, a team is formed that "buys" the idea from a source (section or individual) within the organization and brings that idea forward to the commercialization stage. Members of the team are recruited, not assigned, and typically represent a range of disciplines found within the company, the mix of skills depending on project requirements. At 3M, at least 25 percent of each venture team's sales must be of products that did not exist five years ago.

Small group activities harness and direct the day-to-day expertise of floor workers and their supervisors toward operations management and refinement. These group activities allow the communication of policies and objectives from management to workers and also encourage technology transfer from small groups to the management level. Their scope, while including questions of quality, extends well beyond quality

control circles. Their adoption has usually followed a three- to four-year period during which management is thoroughly oriented to the concept and their commitment to it is secured. A typical group consists of eight to 12 people and is highly democratic, with each electing a leader from among its members. The groups are on equal footing with management in that both are equally responsible for submitting suggestions for improvement.

At Hitachi's Musashi Semiconductor Works, 98,347 improvements were completed through small group activities in 1981 (on the basis of an average 39 proposals submitted per worker). Of these, 27 percent resulted in inventory reductions, 26 percent cut the work time required at individual work stations, 24 percent increased the efficiency of office/clerical functions, six percent produced safety improvements and six percent reduced overhead costs. Small group activities are widely employed in Japanese industry.

The underlying idea of just-in-time inventory management is that any inventory not absolutely essential to sustaining production is waste and should be eliminated. Reducing inventory levels exposes the sources of production problems, be they long set-up times, poor equipment or erratic performance. Accordingly, quality is enhanced, capital equipment is used more efficiently and, of course, inventory carrying charges are reduced.

In Ontario, the adoption of just-in-time is leading to closer, more synchronous relationships between suppliers and original equipment manufacturers. In July, 1983, for example, Hayes-Dana (Chatham) began to supply International Harvester's Chatham assembly plant with front- and rear-wheel axles, drive shafts and torque rods on a just-in-time basis. Hayes-Dana must respond to volume variations on the International Harvester assembly line, without sacrificing parts quality. The two

companies have worked together closely in implementing the system and deliveries are now made to International Harvester twice daily. International Harvester benefits from higher-quality, lower-cost parts, while Hayes-Dana benefits from a long-term supply contract and the experience with just-in-time.

Statistical process control (SPC) has enabled Court Valve of St. Catharines to achieve a number one supplier rating from General Motors - the first Canadian company to have received the award. SPC has supported high-quality production by enabling the company to predict the ability of a machine or process to produce consistently within specifications, to verify that production specifications are being attained and to analyze operations in order to identify the causes of defects and the potential for improvements.

Results achieved to date have been impressive: the in-plant reject rate has declined from 6.5 to .4 percent and the final audit reject rate has dropped from 2 to .05 percent. During the 1983 model year, the company shipped 3.5 million pieces, consisting of 33 different components, to General Motors and had no rejects.

Court Valve has an active SPC training program to ensure that employees build quality into the product. The company plans to extend the application of SPC to include buying and researching new equipment and working with machinery builders to improve existing equipment.

Improshare, or "improved productivity sharing," is a structured plan for involving employees in increasing productivity. Improvements are measured against a base period, with employees sharing in greater monetary rewards. Other benefits include higher job interest, lower absenteeism and improved labour-management relations. At Cardinal Meat Specialists in Toronto, for example, productivity gains under Improshare averaged 25 to 30 percent during the first 11 weeks, while employees have displayed markedly more flexible attitudes toward traditional work rules.

CHART 3-4

MAXIMIZING TECHNOLOGY'S POTENTIAL ON THE PLANT FLOOR AND IN THE OFFICE

Organizational

. Quality control circles (QCC)	. TRW, Ltd., St. Catharines
. Venture teams	. 3M, Minneapolis
. Small group activities	. Hitachi, Japan

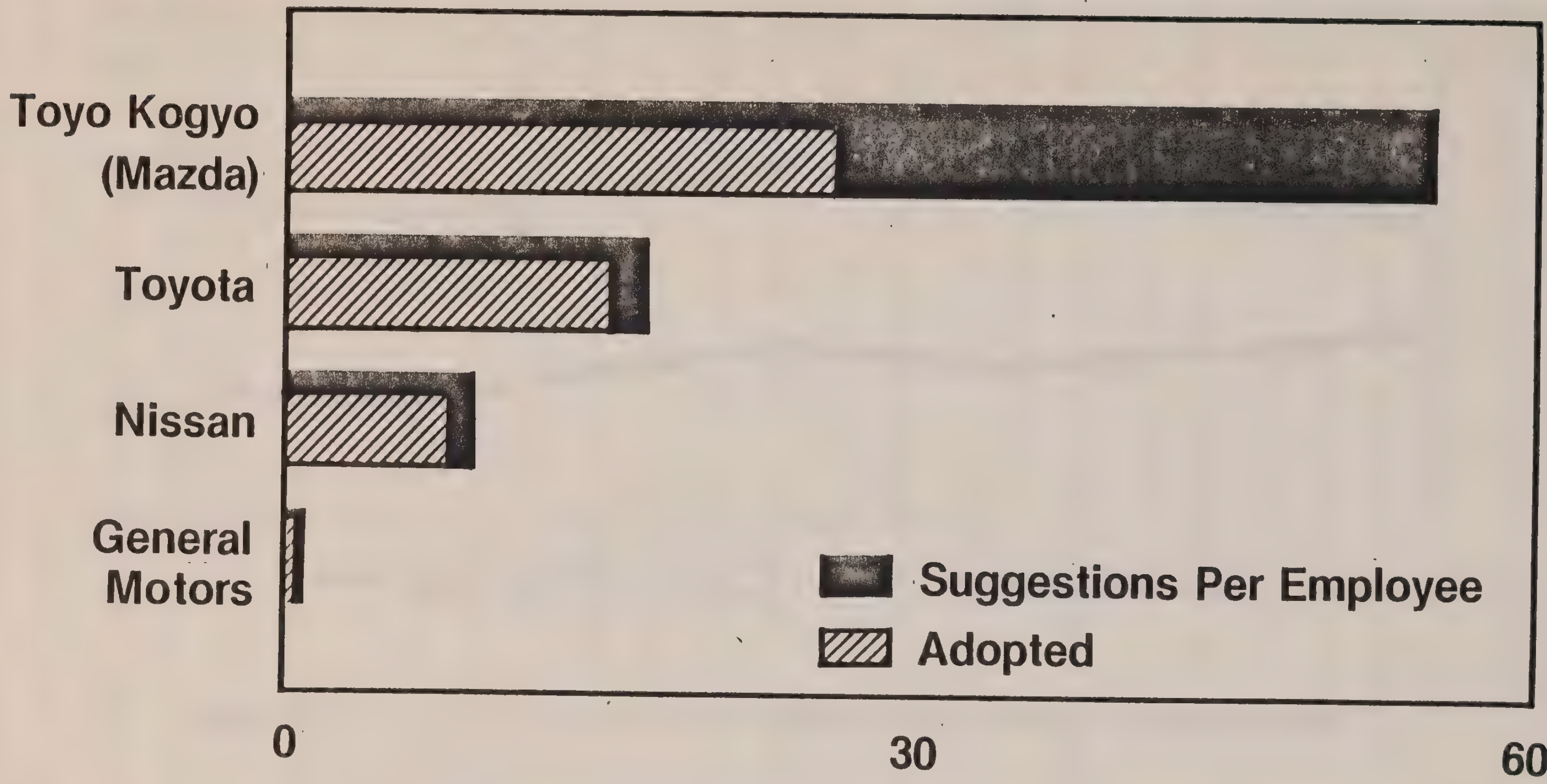
Techniques

. "Just-in-time" inventory control (Kanban)	. Hayes-Dana, Chatham
. Statistical process control (SPC)	. Court Valve, St. Catharines
. Improved productivity sharing (Improshare)	. Cardinal Meat Specialties, Toronto
. Gatekeeping	. Linamar Ltd., Ariss, Ontario (see Case Example #3, page 112)
. Group technology	. Diemaster Tools, Mississauga (see Case Example #4, page 114)

The management methodologies listed in Chart 3-4 are designed to be implemented in concert. For example, quality control circles often direct statistical process control or suggestion programs to achieve "right-the-first-time" objectives. In the context of such a coordinated approach, quality control circles enhance productivity, but are not intended as the sole management solution.

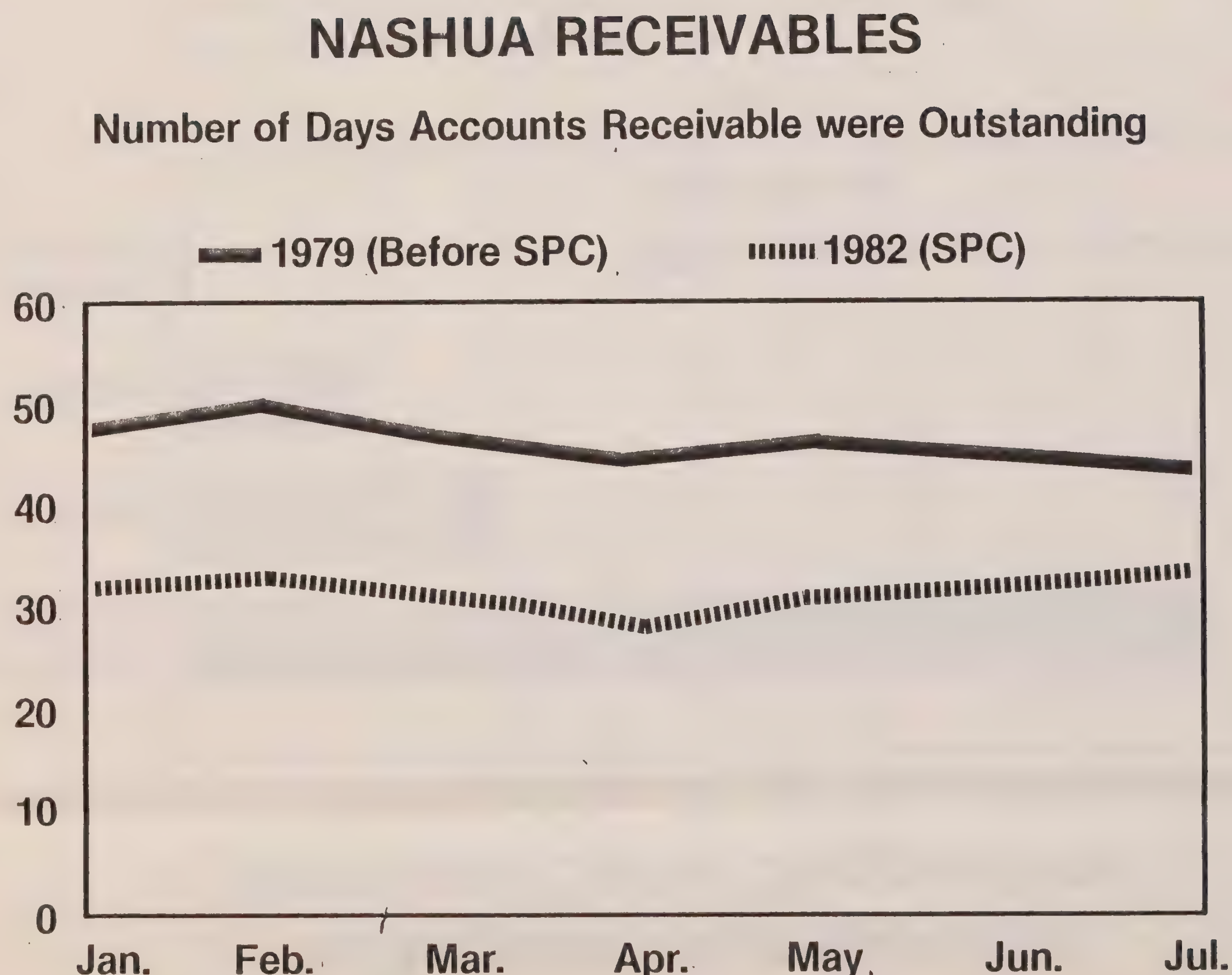
Chart 3-5 places the use of the employee suggestion program in an international perspective:

Participative Management: More and Better Suggestions



Note: Suggestions per employee, 1980.
Source: R. Cole, "The Japanese Lesson In Quality", 1981;
Toyo Kogyo, "1981 Annual Report".

Chart 3—5


NASHUA RECEIVABLES
Number of Days Accounts Receivable were Outstanding
1979 (Before SPC)
1982 (SPC)
60
50
40
30
20
10
0
Jan.
Feb.
Mar.
Apr.
May
Jun.
Jul.
Chart 3—6

As illustrated, some of these management methodologies are currently being implemented in Ontario. Most are in their infancy, often trailing Japanese experimentation and development by more than a decade. Ontario does not have a formal system of advance intelligence and reporting, a key building block for Japanese strategic successes. Nor is Ontario likely to rapidly implement a comprehensive system of worker redeployment or retraining as in Japan. Implementation of some of these management methods has met opposition in Ontario. Quality control circles programs have failed in some cases and in others have been rejected initially as overly problematic for management.

However, early evaluations of the contribution of these methodologies to productivity and competitiveness using the North American managerial measure of results are impressive. Chart 3-6 shows the performance results of statistical control at Nashua in Peterborough as an example of potential implementation in Ontario's manufacturing and service sectors. The methods are also exerting a very real business influence, as reflected in the following remark of a senior GM representative at a recent Quality Seminar at the Automotive Parts Technology Centre: "A supplier who is not able to supply consistently high-quality parts to us and able to back it up with proof of process control simply does not have a future with GM."

A survey of Canadian automotive parts suppliers conducted in 1982 by the Automotive Parts Manufacturers Association provided a consensus forecast of the expected near-term implementation of these management methods in relations with the auto companies. Of more than 150 companies surveyed, 73 percent anticipated self-certification of quality, 73 percent expected widespread adoption of just-in-time production and 58 percent expected that more reliable order scheduling would be required of them.

5. MANAGING TECHNOLOGY IN ONTARIO

Recent experiences with technology in such industries as auto, clothing and footwear illustrate the need to reconsider some of Ontario's sources of competitive advantage. This province has traditionally offered the investor a highly skilled labour force, sophisticated management and a sound organizational infrastructure. Cheap labour, as found in developing countries, is not Ontario's competitive advantage. If Ontario industry cannot compete as effectively for assembly dollars and jobs, then it must compete in the high-ground, value-added investment areas, where sophisticated workers and management jointly offer attractive returns. It is imperative not to lag in, or abandon, this management and organizational thrust, nor to deny the training and educational support required to continually renew Ontario industry as a leading-edge, productive reality in the 1980s. Offsetting the low labour costs and other advantages of many offshore producers demands that Ontario industry place a premium on organizational efficiency, as well as on equipment productivity.

Ontario and its managers must not view its industries, services and educational system as mature management products. To so limit its objectives and investments courts the danger of consigning its economic strategies and therewith the prospects of its key industries to failure. Managing technology, maximizing its input to Ontario's competitiveness and investing in the training and support for such management are the keys to Ontario's future. The following case examples draw on the current efforts of selected Ontario companies in order to document how its industries are preparing for the future. In doing so, these case examples also illustrate several of the adjustments that other Ontario industries will have to make in order to remain competitive.

CASE EXAMPLE #3

LINAMAR MACHINE TOOLS LIMITED
Ariss, Ontario

Linamar's precision machine tooling shop has constantly upgraded its NC and CNC machines since 1968, when it became one of Canada's first shops to operate an NC machine. Eight new machines have been purchased this year, to replace NC equipment one to five years old, and three new CNC pieces are currently on order. The current 38 NC and CNC machines require two full-time computer programmers on day shift and one on evening shift.

More than 90 percent of the company's output is exported, the bulk to the United States. Linamar's president, Frank Hazenfratz, daily reads "Commerce Daily" to scout bid requests, and subscribes to a gatekeeping service that provides computerized historical records of all relevant open bids and bidder information. Hazenfratz sees major productivity improvements through the new equipment's reduced downtime, but stresses that at the same time technicians are needed to harness the new technical capabilities.

Table 3-2 illustrates major productivity measures afforded by Linamar's newest machine tool equipment.

TABLE 3-2

Productivity Measure	2-3 axis CNC machines 1983	Older NC machines 1-5 years old
1. downtime	close to nil	up to 10% of time
2. maintenance	close to nil	up to 20% of time
3. scrap ratio	1%-2%	up to 5%-6% of material
4. floor space	30%-50% less/machine	
5. positioning time	50% less/function	
6. controls	greater CAM capability built into machine = less memory/ instructional stress on instructing computer	all hardware controlled = no editing while machine is performing
7. process heat	much less generated = less impact on integrated circuitry performance and life	
8. tool change time	. some savings, depending on job (see automated tool pre-setter, notes, below)	
9. accuracy	. greater, plus repeatability, and stability	

Notes on new equipment:

A. shuttle table
- . loading time next to nil, and set-up time of less than 15 minutes versus up to 50% of input/output time without this configuration.
- . worker can operate two or more machines simultaneously.

B. automated tool pre-setter
- . allows continuous machine usage, last job continues while pre-setter sets up: savings up to 5 hours on machine set-up with 10 tools.
- . cost: $50,000, plus 800 tool-holders machined on premises, plus duplicated tools.
- . payback: less than one year.

C. tool changer attachment
- . changing time is 40 seconds/cycle. vs. 2.5 minutes/ cycle previously.

D. The newest CNC machines cost just under $100,000-$200,000 and have greater capabilities than their replacements, some less than three years old, which cost $250,000 in some cases.

CASE EXAMPLE #4

DIEMASTER TOOLS INC.
Mississauga, Ontario

George Yui, president of Diemaster Tools, Mississauga, was this summer named "Number One Canadian Toolmaker" by the Japan Mold and Die Manufacturers Association. His plant won the National Productivity Award's 1983 Gold Medal - Production Systems. Pratt and Whitney Aircraft awarded the company a Special Performance Supplier Merit. These testimonials for 11-year old Diemaster confirm impressive performance results during the past decade: sales have doubled annually since 1972: employment has risen from three at start-up to 120 now, including 30 apprentices: more than 75 percent of product is exported: and present plans include numerous projects under foreign licenses and a doubling of plant size within the next five years.

Such success is attributed to a commitment by Yui and his company to three principles, in combination: utilizing the best and most modern technology in production, undertaking continuous training, in-house, and creating the most productive working environment for all Diemaster employees. Together, these resulted in a productivity gain of more than 20 percent in 1982 in the company's new plant. The following notes and charts summarize some of the more significant features of the Diemaster approach to productivity.

1. New Machining Technology: CAM

Diemaster specializes in non-traditional, high-precision machining, turning out high-tolerance machine parts, dies, tools, jigs and molds serving the aerospace, defense and nuclear industries. Metal stampings ranging from 15 to 500 tons are produced. The plant harnesses outstanding tool and equipment capabilities, including a number of four-axis CNC machining centres and three CNC wire electrical discharge machines (EDMs) that supplement four conventional EDMs. This technology is driven, in CAM fashion, by a Digital PDP 1134 computer.

The effective exploitation of such capability, however, remains dependent on Diemaster's commitment to managing the technology.

2. Training: Skills to Direct Advanced Technology

Yui succinctly summarizes his commitment to training his workers: "The shortage of skilled manpower was the only barrier in the way of my company's future growth; training has become a form of survival."

Diemaster currently has 30 apprentices on the plant floor, each pursuing a five-year training program. The in-house program is supplemented by four hours a week at a community college, and also includes one hour a week of mathematics taught by a Diemaster supervisor. The company's search for suitable training manuals resulted in purchases from Great Britain. Diemaster now sells this material both to schools and to its competitors. Training is not confined to apprentices. One in five employees has voluntarily undertaken evening workshops on computer programming at the plant.

3. A Productive Working Environment: Human Engineering

In 1981 Yui set about to design a new plant facility whose environment would stimulate greater productivity. His specifications so perplexed architects and engineers that he became his own general contractor; building inspector intransigence forced him to learn the building code; and sceptical mortgage institutions turned him toward government financing. A number of features of Diemaster's new plant are contrasted with conventional medium-size industrial plants in Table 3-3.

TABLE 3-3

DIEMASTER'S ERGONOMICS: FACTORY OF THE FUTURE, TODAY

Feature	Diemaster	Conventional
1. light	. narrow vertical windows . 87 skylights	. few or no windows . closed roof . windows in management suite
remarks:	. natural light environment saves artificial lighting, is consistent with weather, reduces tension and increases concentration . vertical windows allow light deep inside plant and the light cannot be blocked by machines: sun passes in one hour: workers enjoy visual contact with outside, as at home . monotonous CNC machines are given priority location near windows, to compensate operators	
2. air handling	. systems separated	. heating, air conditioning and exhaust all combined
remarks:	. separate systems allow numerous combinations in controlling plant temperature, while conserving energy resulted in 90% savings . air changed six times/hour	
3. offices	. in middle of plant . look out on plant through windows	. "front" office . separate from plant, look outside
remarks:	. increased access to tool crib, shop management, project room and washrooms = radial vs. linear traffic, resulting in reduced walking time (average aggregate saving of seven hour of productive time/day) . visual contact both ways . encourages good communications, cooperation vs. separation . office provides back-up to workers	

TABLE 3-3 (cont.)

DIEMASTER'S ERGONOMICS: FACTORY OF THE FUTURE, TODAY

Feature	Diemaster	Conventional
4. layout of functions		
	. e.g. purchasing - next to estimating and engineering: also looks out on shipping, for close communication	. at front door for visitors: separated
	. e.g. quality control area placed between shipping and floor, for goods both in and out	. location varies
5. landscaping		
	. trees and plants on shop floor, under skylights	. in front office
	. concrete floors in management offices	. carpets and executive furniture
	. front reception area with tellers booth = receptionist has other tasks	. receptionist in open = single duty
6. plant doors		
	. swing-type	. overhead
remarks	. swing doors are easier to operate, and conserve energy	
7. office heating		
	. buried in concrete floor	. wall or floor mounted
remarks:	. frees up space, decongests floor area	

4. Management Commitment: Productivity Prerequisite

Diemaster productivity is based on the combined application of technology, productive working environment and training. Diemaster's management attitude lies at the heart of such conviction, as stated by George Yui: "The man on the shop floor is the most important... he's making the profits. In Canada we have a negative attitude towards the blue collar worker. In the eastern countries you would find that the skilled blue collar workers are the elite, and they are treated as such."

Diemaster's quality control system plays an important part in productivity. Yui says it is designed "as a reject prevention system, constantly evaluating process capabilities via statistical control, having zero defects as an ultimate objective. It is impossible to inspect quality 'inside' at a later stage."

Yui says the lack of technical people in top level management is one of the major problems in the industry: "If you look around our North American continent at top level industrial management, you will find people with accounting and business degrees. These people know how to count the money but they do not know how to make it."

Short-week cutbacks are self-defeating, Yui believes. "The only answer is to produce volume at a price the customer can afford, which means higher volume at lower profit margin attitude."

Diemaster has never laid off workers. During the recent recession, when it introduced both wage concessions and an extended work week, only a few employees left the company.

CASE EXAMPLE #5

CONESTOGA COLD STORAGE
Kitchener, Ontario

Entering a field pioneered by Canadian Tire for its own in-house distribution system, Conestoga Cold Storage became the first automated public warehouse in Canada three years ago. The company now runs what president Larry Laurien describes as "CAW" - computer-automated warehousing - manufacturing's CAD/CAM operation applied to the distribution sector.

Conestoga has designed and built a double-shuttle AS/RS (automatic storage and retrieval system) materials handling system, driven and directed by a computerized control system. The AS/RS handles 100 two-way pallet transactions an hour in the cold storage area, utilizing two robotic stacker cranes, each loaded with independent software. The computerized control system (Penquin) not only provides complete inventory control through the AS/RS interface, but also maintains all business and management related information, including invoicing, shipping orders and remote generation of on-line customer account status. Both systems are of Conestoga's original design, and the Penquin system is currently being marketed in North America. The software has been designed to be user friendly, allowing Conestoga employees, as well as their customers, easy access to and manipulation of information without need of on-site computer personnel. Penquin's developers assert that "any warehouse employee can do another warehouse employee's job."

The design of Conestoga's cold storage building is also integral to effective AS/RS materials handling. The storage or rack shelving units have replaced conventional structural steel as the building's support.

The 80-foot height provides minimal roof area, replacing square footage floor area with cubic footage storage area. with consequent reduced land requirements. Advanced steel and foam-core wall curtains yield an R34 insulation value. The interior environment is unlit and with AS/RS requires neither worker nor forklift to operate at -23°C.

Canadian Tire's Brampton AS/RS operation, first-phase. cost $6 million and reported an 18-month payback. However, Laurien adds: "The reason for going to an automated building was not purely cost justification in the sense normally used by large corporations. Our first concern was continuing in the cold storage business."

There has not been a lay-off in the Canadian Tire AS/RS operation, while Conestoga, now with the third largest cold storage capacity in Ontario, has added significantly to its capacity while keeping its staff level at 15.

Table 3-4 highlights some of the productivity advantages of Conestoga's integrated AS/RS and Penquin systems.

TABLE 3-4

Productivity Measure	Computer-Automated Warehousing (CAW)	Conventional Warehousing
1. material handling	. 2 automated stacker cranes plus 1 operator outside area . error-free . no materials damage . security guaranteed (lower insurance premium)	. 12 forklifts, each with an operator . labour and machines, with cold environment problems . damage occurs . goods security requires monitoring
2. inventory control	. real-time accounting, on-line: 100% accurate	. historical reporting, with confidence limits
3. customer access	. direct, on-line through modem . immediate shipping response . information security (coding) . total account status	. required search and reporting preparation . security difficult = loss of account status
4. business/ management information	. immediate, on-line invoicing, receipts, pricing and price changing: collapse of "information float"	. manual preparation by warehouse staff plus clerical staff processing . slow price response
5. performance/ guarantee	. can be and is specified by customer in contract	. track record reliability only "counted upon" by customer
6. AS/RS compatible building design		
. space utilization	. 100% cube access	. 67% floor access (square feet), with constant shuffling for access
. energy consumption	. 35% savings on large ticket expense item	

CASE EXAMPLE #6

(a) CGE CAD/CAM MOLD MAKING OPERATION
Cobourg, Ontario

Canadian General Electric established its CAD/CAM Mold Making Operation in January, 1981. This pioneering effort was the first such operation in Canada, and has provided CGE with a single manufacturing process for the production of plastic molds from design inception through to a fully machined end product. The company has developed this process through software development integrated with turnkey computer graphics systems and computer numerically controlled (CNC) machining centres and trained for its direction in house. The company's skilled designers and machinists, not computer personnel, direct and operate both the CAD and CAM technologies. Designers create mold geometry descriptions using either electronic part descriptions or conventional drawings supplied by customers, primarily from the U.S. CNC toolpaths are automatically created using the data base created by the designers. Freed from menial tasks such as drilling and scribing, the machinists can concentrate full time on top-end skill applications such as grinding and fitting.

Table 3-5 highlighs some of the effects new technology has had on productivity at CGE's Cobourg plant.

TABLE 3-5

CAD/CAM Mold Making: Software/Hardware Synergy

Conventional	New Technology	Productivity Effects
. manual drafting . paper transfer . prototyping and models (3D CAD is substituted for physical) . interpretation	. CAD/CAM computer graphics system and customized applications software	. labour savings . lead time improvement . process description (increasing manufacturing linkage) . problem identification and premachined modification with ease

TABLE 3-5 (cont.)

Conventional	New Technology	Productivity Effects
. manual machining	. CNC machining centres (4), CAM	. labour savings . increased operational time (durability) = shorter cycle time . stability (motions repeated properly and accurately) . material savings = more accurate costing and inventory control planning . increased tool life (through directed spool tachometry) . accuracy, confidence are unbeatable (bypass foam prototype, direct to metal mold) . frees skilled machinist's time for complex tasks: increased utilization of workers' skills inventory
	. electrical discharge machines (3)	. as above . provides capability for small and deep ribs, deep narrow cavities and sharp corners

b) COMPLAX CORPORATION (FORMERLY CGE) MOLDING OPERATIONS Cobourg, Ontario

With the opening of its Cobourg plant in 1947, CGE became one of Canada's first custom molders. Today its plastic molded parts serve the automotive and consumer industries. In the past three years this business has become a world leader in the injection molding of glass-filled thermoset plastics. With the innovative use of materials handling and finishing robots, combined with the computerized operation of machinery, labour costs have been reduced substantially, while maintaining high quality at world competitive prices. Elements of technology are treated

as building blocks for continual productivity upgrading through integration with hard automation production points.

Table 3-6 highlights some of the effects new technology has had on the productivity of Complax's Cobourg plant.

TABLE 3-6

Molding Operations: Enabling Hardware

Conventional	New Technology	Productivity Effects
. manual unloading from press	. pressworking robots (2)	. safety . reduced cycle time . fewer handling sequences . expandable capabilities
. manual linkage between hard automation points (press and machine) . manual deflashing through filing	. materials finishing robots (2), programmable contouring capabilities by means of water jet delivery through five-axis manipulation	. improved product quality . replace manual functions
. manual handspraying of various parts	. painting robot	. accuracy and consistency (materials saving) . labour saving . environmental improvement (safety)
. manual handspraying	. electrostatic painter, dynamically adaptive through programming terminal, directed by lines sensors	. as above . flexibility without manual adjustment
. manual machine setup	. microprocessor based programmable controllers on machines with magnetic card setup	. reduced setup time . consistency in molding machine parameters from one setup to another

CHAPTER 4

TECHNOLOGY:

FEDERAL AND OTHER PROVINCIAL GOVERNMENT ACTIVITIES

TABLE OF CONTENTS

CHAPTER 4

TECHNOLOGY: FEDERAL AND OTHER PROVINCIAL GOVERNMENT ACTIVITIES

1. INTRODUCTION

In Chapter 1, the level of investment by the public and private sectors in other countries to support technological development and application was reviewed. This provides a broader context within which to review the initiatives to support technology at the federal level and in other provinces in Canada. This is followed in the next chapter by a review of Ontario's initiatives.

While Ontario has taken a lead, through the establishment of its Technology Centres and IDEA Corporation, to assist in the adoption of, and investment in, new technologies, other jurisdictions in Canada are also assisting industry. In reviewing their programs, it is possible to discern some general trends, although the approaches may vary. First, there is an increased effort to encourage technology transfer and modernization of industry. Second, there is a major focus on productivity improvement and product development. Third, a strong emphasis has been placed on supporting high-technology industries through industrial assistance and capital grants. Finally, other provinces are working closely with the federal government in creating a supportive climate to nurture the growth of technology industries.

On June 16, 1983, one of the issues discussed at the Canada-Ontario General Development Agreement was the proliferation of government science and technology programs and services to meet industry needs. The ministers expressed concern over the possibility of duplication and a common desire to see greater federal-provincial cooperation and

coordination in this area. In response, the Ministry of Treasury and Economics and the Ministry of State for Economic Development have recently prepared a report entitled "An Inventory and Review of Canada-Ontario Science and Technology Programming" for the purpose of identifying areas of potential collaboration. This provides an excellent reference document.

It should be noted that, in addition to the federal and provincial initiatives reviewed in this chapter, there are many private and municipal activities to support technological development and application. These have not been reviewed in this paper.

2. FEDERAL GOVERNMENT INITIATIVES

This section will briefly review the federal government's recent policy and program initiatives relating to science and technology. In summary, an attempt has been made to provide a statement of what the federal government has recently announced. While the individual objectives set forth for each sector of the economy are comprehensive, it is not possible to critically evaluate the outcome of these policy initiatives until they have actually been implemented.

A. Federal Technology Policy

The April 19, 1983, federal budget allocated more than $700 million to technology development in the next two years. In May, 1983, the Minister of State for Science and Technology and for Economic Development announced a technology policy for Canada.

The federal government stated that, to be fully effective, a technology policy for Canada must act with and through economic, fiscal and industrial policies. As science and technology range across all major federal departments, technology development must be addressed as an integrated policy area with separate but synergistic components. In recognition of the complexities of linking science and technology goals in support of national economic objectives, a special sub-committee of cabinet on technology development has recently been established. The sub-committee is mandated to integrate policy elements and to advance technology development in all sectors.

The broad goals of the federal technology and economic development strategy are:

- to strengthen the Canadian economy through the development of new technologies for producing goods and services and the widespread adaptation of new and existing technologies:
- to manage the process of technological development to ensure that Canadians are aware of opportunities and problems;
- to ensure that the benefits of technology development are shared equitably among all regions;
- to create a social climate that places a premium on scientific and technological excellence, curiosity and innovation.

To carry out these goals, the federal government has set specific objectives related to its interactions with each sector.

a) The Business Sector:

The objectives relating to the business sector reflect the primary role of the private sector in initiating innovation and new investment. These are:

- to provide an overall business environment that encourages investment, innovation and enterprise:
- to ensure that the current industrial support programs for technology development are working as effectively as possible toward achieving economic and technological objectives:
- to ensure that firms operating in Canada are aware of, have access to, and apply the most productive technologies available to ensure their continuing competitiveness;
- to ensure the development of internationally competitive high-technology industries in Canada, suited to our knowledge, resource and industrial base:
- to ensure that industry is able to obtain the best technological forecasting and assessment information.

b) The University Sector:

The objectives relating to the university sector are:

- to create a core of excellence within the university structure that undertakes research relevant to industry;
- to form the research human resources required to meet the objectives of the technology policy;
- to increase the responsiveness of universities to the research and technology of industry;
- to make industry more aware of the contributions that universities can make to the process of technology development.

c) The Labour Sector:

The objectives are:

- to encourage labour-management mechanisms at the firm, industry and national levels that will permit joint planning for technological change;
- to support labour in studying the issues brought about by technological change and in educating labour and the general public on these matters from a labour perspective.

d) The Federal Government Sector:

With respect to R&D performed or funded by government, the objectives are:

- to ensure that all federal programs and policies related to technology development effectively contribute to overall federal objectives for technology and economic development;
- to ensure that research undertaken in federal laboratories is relevant to industrial requirements and compatible with the stated economic objectives:

- to ensure that Canada develops and maintains a national competence in the research necessary for technology development.

e) The Provincial Government Sector:

The objectives related to the provinces are:

- to achieve compatible policies and programs;
- to provide an environment that encourages interprovincial cooperation.

f) The Public Sector:

In an effort to support individuals and institutions in anticipating and responding to the changes and opportunities raised by technological development, the federal government has set the following objectives:

- to ensure that all Canadians are aware of the implications of technological change to their lives;
- to anticipate the impact of technological change, and to minimize its negative effects, in close consultation with those most likely to be affected;
- to provide access to training and educational opportunities;
- to ensure that all individuals have similar ranges of opportunity, and that all regional economies take advantage of technological opportunities in line with their comparative advantages.

B. Federal Programs

The federal government currently supports a wide range of programs and initiatives to assist and encourage technological

development in Canada. There are 57 federal departments and agencies involved in science and technology expenditures. Further detail on each of the following areas is provided in Appendix A:

- tax incentives;
- financial assistance for research and development;
- scientific and technical information;
- training assistance;
- technology support through procurement;
- technology support through institutes;
- departmental programs;
- intellectual property.

Examples of recent federal initiatives to foster technology development are summarized here.

a) The April 19, 1983, Budget Initiatives:

The budget allocated $700 million for technology development. This is in addition to the $3 billion budgeted for technology support in the 1983/84 estimates and the $1 billion budgeted for science and technology acitivities performed in the university and industry sectors. It also excludes the $200 million of foregone tax revenue for current R&D expenditures, as well as the $185 million that new tax changes and other proposals would add.

i) Tax Incentives:

In response to requests from industry, improvements in tax incentives to enhance the ability of particularly smaller firms to benefit from them have been proposed. These changes would make the incentives simpler and more effective, and allow R&D-performing firms to use tax incentives to attract outside financing.

ii) Improved Research Facilities:

Under the Special Recovery Capital Projects Program, research and training facilities critical to advancing new technologies will receive accelerated funding totaling $290 million during the next four years. Sixteen new and expanded research facilities will be built across Canada. Projects are expected to substantially expand research in the forest products, fisheries, agri-food, manufacturing and mining industries. In addition, approximately $180 million will be allocated for high technology procurement.

iii) Human Resources Development:

The federal government's stated objective is to anticipate the impact of technological change in order to minimize its negative aspects. An additional allocation of $155 million for human resource development programs will bring to a total of $1.2 billion the amount allocated for skills development in occupations that are significant for economic growth.

b) Recommendations of the Sub-Committee on Technology Development:

The following new initiatives, costing $100 million in the next two years, have been carried out or are in the process of being carried out.

i) Productivity and Technological Adjustment:

A total of $10 million has been approved during the next two years to encourage business and labour to establish a Centre for Productivity and Employment Growth, to be located in Winnipeg. The centre's overall direction will be defined by business and labour, with initial funding provided by the federal government.

ii) Regional Support:

The federal government will spend $20 million during the next two years for regional technology development through expansion of the National Research Council's Industrial Research Assistance Program. Services to small- and medium-size businesses will be expanded to help solve manufacturing problems, improve productivity, promote the use of research results in industry and generally diffuse needed technology.

The federal government is also strengthening its support of joint university/industry technology research efforts with the objectives of:

- generating a core program in a field of specialization and developing new technologies;
- training the research personnel required by industry in the development and application of advanced technologies and to teach postgraduate courses;
- performing specific R&D for participating industries, carrying out joint research programs and performing contract research.

Potential areas include microelectronics, artificial intelligence, biotechnology, materials research, manufacturing technologies and space technologies.

iii) University Support:

Increased funding of almost $27 million will be provided during the next two years to the Natural Sciences and Engineering Research Council, the largest single funder of university-based research in Canada. A further $9 million during the next two years will be spent to strengthen joint university/industry research and technology efforts.

iv) Microelectronics:

The federal government will be establishing a National Microelectronics Design Network comprising a nationwide. university-based, computer-linked network of design and testing stations for VLSI chips. An initial fund of $7.5 million over two years has been allocated. The design network is an extension of a project currently supported by the Natural Sciences and Engineering Research Council in conjunction with Queen's University and Northern Telecom Canada Ltd. About 30 universities are expected to participate. These facilities will help provide the trained and experienced human resources that are critical to the expansion of the Canadian microelectronics industry. In addition, they are expected to enhance collaboration between industry and universities as well as develop opportunities for software research.

This, in conjunction with the new IRDP, which replaces STEP and IAP, will constitute the government's efforts to bolster microelectronic development in Canada. Under the old programs, $200,000 a year over five years was committed to establishing a microelectronics centre in each province. To date, seven centres have been set up in universities and the three remaining provinces are under review.

v) Biotechnology:

The federal government has committed $22 million toward implementing a National Biotechnology Strategy. Its first priority will be establishing research networks in government, universities and industry and concentrating efforts in areas of critical importance to the economy. The federal government will encourage strong cooperation between universities and industry by matching all industrial contributions with

federal funds. The networks will focus on improving the use of Canada's resource base and on industrial development.

A national biotechnology advisory committee will advise on all matters related to biotechnology. A biotechnology Centre was opened in Waterloo in October, 1983. Under the federal Special Recovery Capital Projects, a Biotechnology Research Institute in Montreal has recently been announced and an Agriculture Biotechnology Centre is under way in Saskatoon.

vi) Communications:

To further develop communications technology, the federal government is proposing the creation of a Canadian Communications, Informatics and Space Research and Development Institute. As a nonprofit corporation, it will conduct research and development in telecommunications, space technology, informatics and computer sciences. A task force will assess the viability of the proposed institute.

vii) Public Awareness:

The federal government is establishing an annual fund of $1.5 million to promote public awareness and understanding of science and technology and the impact that developments in this area will have on the Canadian economic and social environment.

Several observations can be drawn from the preceding review of federal government initiatives. Many of the initiatives and programs funded by the federal government to promote technological development and application are supportive of Ontario's initiatives and manufacturers' needs. They will provide a valuable resource to programs such as the Technology Centres in terms of research, information and expertise, which can then be made available to manufacturers. Now that provincial

governments are increasing their role in establishing technology centres, duplication of effort may be a problem unless some form of coordination is developed. It will, therefore, be important to establish close working relationships and cooperative efforts to maximize resources and expertise and avoid duplication.

As mentioned earlier, a credible attempt has been made by the federal government in establishing goals and objectives for a technology strategy. However, the pressures on the federal government are such that the appropriateness of its regional focus for technological support is questionable. For example, the allocation of funding for technology development in accordance with regional economic needs is indicated by the establishment of the Centre for Productivity and Employment Growth in Winnipeg, despite the fact that Manitoba has only 2.6 percent of shipments in manufacturing in Canada. The generally diffuse and regional focus of the federal technology policy may not fully complement provincial priorities and industrial strengths to their fullest.

3. OTHER PROVINCIAL GOVERNMENT INITIATIVES

Appendix B, while not inclusive, provides examples of other provincial governments' technology initiatives to support their mature and emerging high-technology industries. Several provinces have also established research facilities and technology transfer centres, which include, among others, the following.

A. Manitoba

The Industrial Applications of Microelectronics Centre was established in 1979 in Winnipeg under the STEP program to improve product development, applied and basic research, and industrial training. The Food Products Development Centre was established in Portage la Prairie under STEP to develop food products and examine more-efficient production methods. The High Voltage Direct Current Centre has been established at the University of Manitoba.

B. Nova Scotia

The Applied Microelectronics Institute was established in 1981 as a cooperative venture with Dalhousie University, the Technical University of Nova Scotia and the Nova Scotia Research Foundation to develop products and carry out cooperative ventures with industry. Nova Scotia has also opened a CAD/CAM Centre at the Technical University of Nova Scotia with the aid of $500,000 from Control Data Canada Ltd. Halifax County Industrial Commission is planning a $23 million technological industrial park at Halifax International Airport with financial assistance from federal and provincial sources.

C. New Brunswick

The New Brunswick Manufacturing Technology Centre, opened in Fredericton in 1981, is a joint project between the University of Moncton and several community colleges, with emphasis on CAD/CAM. CADME Microelectronics Inc. of Fredericton is funded under STEP, with emphasis on industrial training and technology transfer to industry.

D. Prince Edward Island

P.E.I. is considering a link-up with the New Brunswick Manufacturing Centre to keep abreast of emerging technologies.

E. Quebec

The Sherbrooke Industrial Microelectronics Centre was founded in 1981 and is associated with the University of Sherbrooke. This centre focuses on resource, textile, furniture and shoe making industries to improve productivity through the use of microelectronics. Quebec plans to establish eight technology centres by 1986, costing $50 million. To date, it has approved $6 million for a Robotics-CAD/CAM Centre, and expects to approve two more centres by the end of 1983. These two will be concerned with computer software and either biotechnology or transportation.

F. Saskatchewan

Innovation Place, a project of the Saskatchewan Economic Development Corporation, is a science park with such tenants as the Saskatchewan Research Council. In addition to research and product testing, there is a key focus on microelectronics.

G. Alberta

The Venture Capital Corporation, established with $200 million from the Alberta Heritage Savings Trust Fund, complements the activities of the Alberta Research Council and the Alberta Heritage Foundation for Medical Research. Several research laboratories concentrate on agriculture and natural environment research. There is also a Coal Mining Research Centre, as well as a CAD/CAM Centre located at the University of Alberta.

H. British Columbia

British Columbia Institute of Technology promotes and assists in the transfer of technology. A Computer-Aided Design and Manufacturing Centre in western Canada has been proposed for British Columbia by the Western Foundation for Advanced Industrial Technology. It is proposed that the centre be operated at British Columbia Research in contract to the foundation and utilize the resources of the National Research Council and the University of British Columbia. For forestry-related technology, the province relies on its Forest Engineering Research Institute.

As in the case of federal programs, there is a need for Ontario to be aware of, and liaise with, technological developments in other provinces.

CHAPTER 5

TECHNOLOGY:

ONTARIO'S ACTIVITIES

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CHAPTER 5

TECHNOLOGY: ONTARIO'S ACTIVITIES

1. INTRODUCTION

In previous chapters, a picture has been given of the rapidly changing technological, economic and working environment within which individuals, businesses and governments will operate in the next decade. This is an environment that begs for action in order that the changes can be effectively managed. It is also an environment that requires a planned approach across the entire spectrum of economic, trade, technological, educational and training policies and priorities.

It was in recognition of some of the factors that make up this new environment that the government of Ontario initiated a technology program. This program is being implemented through the six Technology Centres and the venture capital operation, IDEA Corporation.

In this chapter a detailed review of the background, mandate, programs and start-up activities of the Technology Centres and IDEA Corporation is provided. Two points, however, need to be made to provide an appropriate context for this review.

First, the program has developed beyond the original intent to provide access to information. In view of industry's resistance to change and the general lack of knowledge about applications being undertaken by competitors, the Technology Centres and IDEA Corporation are mandated to adopt a more proactive role in assisting secondary manufacturers to apply technology than was originally envisioned.

Second, it would be misleading to assume that, despite the approximately $200 million allocated to this program by the government, this investment provides a total response to the economic and technological realities of international competition facing Ontario. The Technology Centres and IDEA Corporation do provide an opportunity for

businesses to obtain expert advice, consultation, information and venture capital to apply technology to their products and processes. However, their success is dependent on the private sector making use of such expertise. A supportive environment based on stable and cohesive economic, fiscal and industrial policies is required to encourage the private sector not only to make use of available expertise, but to make the necessary investments to apply new technology.

This chapter, therefore, describes part of the response to this problem. It is not the intent of this paper to suggest that the Technology Centres and IDEA Corporation are not appropriate and do not have a very real role to play in an overall technology strategy. It is the intent to suggest that the lead the government of Ontario has taken in this program now has to be followed through with an overall cohesive approach. The approach should include greater cooperation to maximize resources between the federal and provincial governments as indicated in the previous chapter. As well, it needs to provide overall direction and priorities for the many other technology-related activities within the Ontario government as discussed in this chapter. Such an approach will allow businesses to fully benefit from the Technology Centres, IDEA Corporation and other government initiatives and achieve their potential as international competitors.

2. THE TECHNOLOGY CENTRES

A. BILD Announcement

The original BILD initiative for technology centres was in response to a low level of manufacturing research and development activity in Ontario and a slow take-up of technology by Ontario manufacturers. It was recognized that Ontario's international competitiveness is dependent on a high degree of product specialization, accompanied by a strong technological effort. The importance of sustaining technological progress to generate overall economic growth has been well documented elsewhere. As well, there are concrete historical experiences of countries such as Japan where technology is used as a major stimulant for economic growth.

The BILD initiative proposed by the then Ministry of Industry and Tourism was based on the concept that technology centres could form a major component in a strategy aimed at significantly improving the technological capabilities of Ontario manufacturers.

Extensive research on the appropriate type and number of technology centres was undertaken prior to the BILD announcement. For example, the ministry commissioned a study by the Ontario Research Foundation with respect to the automotive parts industry. The study found that more than 79 percent of the firms interviewed believed that an automotive parts technology centre could improve their competitiveness. The interim report of the microelectronics task force strongly recommended the early establishment of a microelectronics technology centre. It was recognized that for secondary manufacturers to remain competitive a major effort was required to strengthen the whole process of research and development, venture capital and applications engineering assistance.

The six technology centres announced by BILD were as follows:

Ontario Centre for Microelectronics	- Ottawa
Ontario Centre for Advanced Manufacturing	
CAD/CAM	- Cambridge
Robotics	- Peterborough
Ontario Centre for Automotive Parts Technology	- St. Catharines
Ontario Centre for Resource Machinery Technology	- Sudbury
Ontario Centre for Farm Machinery and Food Processing Technology	- Chatham

It was expected that each would establish direct linkages with the wide variety of expertise and resources contained in the others and with technological activities within the private and public sectors. The objective was to create a comprehensive range of services to clients beyond those based solely on in-house capability.

It was not the government's intent to dictate to industries what they should do, but rather to assist them where necessary to remain internationally competitive.

B. BILD Approval of Business Plans

Following the announcement of the type and number of technology centres, consultants from the private sector were retained by the Ministry of Industry and Trade to expand on the background studies and to develop five-year business plans for each centre. The business plans were to provide:

- detailed program and financial plans:
- design and configuration of the proposed structures:
- identification of appropriate equipment and facilities;
- identification of staff requirements.

Cooperation between the government and the private sector was further enhanced by the appointment of interim advisory committees. These were composed of senior representatives from business, labour, academia and research institutions. The committees assisted in the development of the mandate for each centre, reviewed the business plans, advised the ministry on progress, and undertook the start-up operations of the centres.

The Technology Centres Act was passed in July, 1982. Each of the business plans was approved between July, 1982, and December, 1982. The five-year financial plans for each centre are shown in Chart 5-1.

The following section reviews the general concept and unique features of the Technology Centres as well as each centre's specific mandate and programs.

C. Mandates and Programs of the Technology Centres

The Technology Centres act as a catalyst by promoting, informing and assisting primarily small- and medium-size secondary manufacturers to apply technology to their products and processes. They provide applications engineering assistance, information on state-of-the-art technological developments and applications, awareness, training programs for senior management and demonstrations.

In this context, it must be recognized that the Technology Centres are not basic R&D facilities like many of those sponsored by other provinces and the federal government or those affiliated with universities. Rather, the Technology Centres facilitate the transfer of state-of-the-art technology to secondary manufacturers. The centres are proactive in promoting awareness of potential opportunities and assisting manufacturers in actually undertaking applications.

CHART 5-1

ONTARIO TECHNOLOGY CENTRES FINANCIAL SUMMARY[1] ($000s)

	1982-83 Actual	1983-84 Approved	1984-85 Forecast	1985-86 Forecast	1986-87 Forecast	1987-88 Forecast	Total	
Microelectronics								
Operating	1,513	3,775	4,859	5,161	5,441		20,749	
Capital	1,547	2,343	555	545	545		5,535	26,284
Revenue	-	932	2,003	2,764	3,364			9,063
								17,221
Advanced Manufacturing								
CAD/CAM								
Operating	488	2,608	2,971	3,387	3,149		12,603	
Capital	188	2,783	1,250	890	830		5,941	18,544
Revenue	-	483	785	1,138	1,569			3,975
								14,569
Robotics								
Operating	360	1,970	2,321	2,734	2,562		9,947	
Capital	330	2,330	890	550	450		4,550	14,497
Revenue	-	197	488	996	1,225			2,906
								11,591
Central Overhead								
Operating	23	416	664	664	664		2,431	2,431
								28,591
Resource Machinery								
Operating	268	958	807	850	920		3,803	
Capital	140	94	-	-	-		234	
R&D Funding	600	3,800	4,000	4,000	4,000		16,400	20,437
Automotive Parts								
Operating	819	3,116	2,770	2,730	2,710	2,660	14,805	
Capital	50	79	120	35	10	10	304	15,109
Revenue	-	499	665	1,010	1,200	1,335		4,709
								10,400
Farm Machinery & Food Processing[2]								
Operating	260	1,183	1,850	1,970	1,980	1,980	9,223	
Capital	305	498	405	250	150	-	1,608	10,831
Revenue	-	167	830	1,000	1,000	1,000		3,997
								6,834
Technology Centres Gross Total								108,133
Revenue								24,650
Net Total								83,483

The Technology Centres have been established as commercially responsible operations so that business decisions can be made and an effective relationship established with clients. Given that the government has limited resources, the centres are expected to generate revenue by charging clients for their services.

One of the major reasons for creating the Technology Centres was to assist in overcoming the resistance of many industries to technological change. Since the product of the centres is effectively a service, they are expected to operate like any other business in marketing their services. Therefore, they have marketing departments and sales staff who are responsible for promoting their services and expertise. The centres are not to compete with the private sector, but to complement their activities by filling gaps where needs are not being met.

In addition to the commonality in the overall concept of the centres, there are similar features in their operations. As a Schedule II agency, each centre has a stand-alone board of directors, chosen from the business, labour and academic sectors. The boards are responsible for the overall management and supervision of the centres. The board members are carefully selected from senior levels within their organizations. They represent a wealth of experience and expertise with which to advise the government.

A key provision in the operation of the centres is a five-year sunset clause. Each centre will have to justify its continued existence, mandate and costs in relation to the objectives set forth in the business plan.

The following brief review highlights both common and unique features in the mandates and programs of the centres.

a. Ontario Centre for Microelectronics:

The mandate of the centre is to:

- accelerate the diffusion of microelectronics technology throughout Ontario industry and increase the awareness of the general public:
- provide and arrange for design assistance and training programs for specialized microelectronics applications:
- arrange for the production and testing of semi-custom and custom chips using the best available technology.

Programs offered by the centre include:

i) Technical Services:

Application engineering services, feasibility studies and design, simulation and prototype testing of semi-custom and custom chips are provided. The following types of projects and services are undertaken by staff:

- design and implementation of gate array, semi-custom and custom integrated circuits;
- semiconductor supplier selection and interfacing;
- applications of electronics to non-electronic products:
- systems and circuit design:
- microprocessor and process control applications;
- manufacturing methods consulting:
- project review and assessment.

One of the unique features of the centre is its capability to design semi-custom and custom chips. The centre explores new or improved product opportunities with clients, and then defines and specifies the necessary design and development activities. Experienced engineers at the centre perform all or part of a design and development project and assist clients in establishing new production methods.

ii) Training:

Training services assist companies in developing the expertise required to enter the field of microelectronics. A series of seminars and technical courses on the technological, application, design and manufacturing aspects are provided.

iii) Awareness:

To provide proper conceptions about the applications and benefits of microelectronics and employment opportunities, the centre conducts public awareness programs through seminars, presentations and public speaking engagements.

iv) Information Services:

A computerized information service provides access to all major data bases in the field of microelectronics.

b) Ontario Centre for Advanced Manufacturing - CAD/CAM and Robotics:

The mandate of the CAD/CAM Centre and the Robotics Centre is to:

- assist Ontario industry to adapt CAD/CAM and robotics technologies in their manufacturing processes:
- stimulate the growth of Ontario-based supportive CAD/CAM and robotics industries.

The following programs offered by both centres are practical, and directed to manufacturing applications and the needs of staff and management in applying these new technologies.

i) Outreach:

Marketing programs, including industry days, regional seminars and participation in trade shows and exhibitions, are designed to stimulate interest in the technologies and in the services of the centres.

ii) Training and Familiarization:

Training programs are targeted at senior executives and technical managers of businesses. A series of general and intensive workshops on various CAD/CAM and robotic topics are provided either at the centres or at a company site. Assistance is also provided to public and private organizations to identify future training requirements and to modify or develop new programs and curriculae.

iii) Demonstration:

A range of equipment at the centres demonstrates software and hardware applications related to a variety of manufacturers' operations. This provides a practical, hands-on means of understanding CAD/CAM and robotics.

iv) Technical Consulting:

Technical consulting services assist manufacturers to understand the implications of rapidly changing technology and how they can specifically apply CAD/CAM and robotics. The objective of the consultations is to assist clients to reach the right decision and to achieve an effective implementation. The following are examples of consulting assistance:

- plant surveys to identify potential applications;
- feasibility studies and cost/benefit analyses:
- evaluations of vendor proposals.

v) Information Services:

Information on state-of-the-art technological developments and industrial applications are provided through computerized data banks and audiovisual aids.

c) Ontario Centre for Farm Machinery and Food Processing Technology:

The mandate of the centre is to:

- develop, adapt and improve farm and food processing machinery for Ontario conditions;
- provide applications advice and assistance related to productivity and materials handling;
- advise farmers, equipment manufacturers and food processors by providing information and computer and consulting services through extension and technical specialists.

The following programs are being developed.

i) Product Development and Modification:

The centre concentrates on the development of short-line equipment, farm materials handling equipment and specialty crop machinery. It is in these areas that Ontario has the opportunity to develop new products for home consumption that will replace imports and possibly be exported. As well, the centre's pilot plant will focus on fruits and vegetables, and actively promotes the use of microprocessors to increase productivity through automation and control technology.

Several projects have been identified by the centre to date and negotiations are currently proceeding. The centre's staff have also been working closely with Agriculture Canada, the Ontario Ministry of Agriculture and Food, Guelph University and other research facilities. Many of the projects identified in the engineering area are for limited market equipment that in terms of manufacturing provide a small market base but will significantly affect productivity in the agricultural sector.

ii) Information:

The centre's information program provides manufacturers and food processors with access to major data banks throughout the English speaking world. This service includes on-line literature searches and document delivery. The staff liaise with other research and information centres throughout North America. To date, it has completed 18 searches on behalf of clients seeking specific information on a wide variety of products and processes.

d) Ontario Centre for Resource Machinery Technology:

The mandate of the centre is to:

- invest in the development of new equipment that will be marketable to both mining and forestry resource industries:
- participate in activities that will increase or preserve Ontario employment in the resource machinery industry:
- encourage import replacement and development of export opportunities.

The following programs are carried out by the centre.

i) Investment Funding:

Venture capital funding is provided for the commercialization of projects meeting specific criteria. While this aspect makes the centre's operation similar to the functioning of IDEA Corporation, there are three major differences in the approaches of the two organizations. These are:

. The Ontario Centre for Resource Machinery Technology limits its funding to resource machinery applications.

- Projects funded by the centre must have proven market acceptability. This restriction limits funding to applications engineering rather than to high-risk innovative research.
- While the centre serves Ontario industry, emphasis is placed on projects that will benefit Northern Ontario.

To date, the centre has approved, in principle, investment totalling $1.5 million for six projects. These include the development and commercialization of a portable align boring machine, a water pressure rock impacting machine and a feasibility study for a tunnel extruder.

ii) Economic and Market Analysis:

In addition to rigorous feasibility analysis for projects under consideration, the centre is developing a full range of information concerning resource machinery manufacturing opportunities, both domestically and internationally.

iii) Communications Program:

Specialized seminars and general forums have been undertaken to assist manufacturers and resource industries. These include supplier/buyer liaison, productivity improvement, export market development and new product development.

iv) Advisory:

Policy advice is provided by the centre to industry and government to improve export opportunities and reduce dependence on imported machinery and technology.

e) Ontario Centre for Automotive Parts Technology:

The mandate of the Automotive Parts Technology Centre is to:

- bring together the interests of parts suppliers, automotive companies, unions, universities, research organizations and governments to enhance the long-term competitiveness of the auto parts industry;
- promote and stimulate technological developments by providing companies with basic management consulting services:
- disseminate information on markets and technology:
- coordinate and initiate public and private research related to the needs of the industry.

To accomplish this, the following programs are available to meet the specific industry needs.

i) Manufacturing and Productivity:

The centre offers manufacturing and productivity programs to assist parts manufacturers to implement productivity, quality control and inventory management system improvements. As a coordinator, the centre provides consulting, education, training and shared experience workshops for the exchange of manufacturing ideas. To date, 15 productivity and manufacturing improvement projects have been undertaken. By the end of the fiscal year more than 50 seminars and workshops will be completed on a variety of topics, including statistical process control, quick die change, just-in-time flexible manufacturing and quality circles.

ii) Technology Development:

Technology development programs assist parts manufacturers in developing their capabilities to make innovations in their process and

product technologies. The services provided include technical assistance, technical personnel placement and technology development funding.

The centre also provides financial assistance to clients to stimulate technological development. This includes manufacturing process improvements, product testing and new product and process feasibility studies. To date, six projects have been undertaken with automotive parts manufacturers across Ontario.

iii) Marketing and Information:

The centre, in conjunction with government agencies and trade associations, assists in providing new international marketing opportunities for Ontario parts suppliers. It also brings parts and vehicle manufacturers together to discuss industry problems from a supplier/buyer perspective. Specific services include market intelligence, international marketing and supplier/buyer liaison. The centre carries out a series of marketing seminars for clients interested in export opportunities.

D. Start-up Activities of the Technology Centres

The activities of the Technology Centres Division during its first year of operation have been primarily to assist the centres in their start-up. This has entailed assisting in the development of the business plans; locating suitable premises; recruiting start-up contractors; organizing the official openings; recruiting the presidents and senior personnel; assisting the board of directors; making presentations to numerous associations and institutions; liaising with other government bodies, the media and local communities; developing an umbrella promotions program; undertaking policy projects and responding to a myriad of requests for information.

The official openings of the six centres took place between the end of October, 1982, and the beginning of February, 1983, as the business plans for each were approved. There was a tremendous response to the openings from the business community and the general public. A total of more than 12,000 people attended the openings.

Each of the centres has been actively engaged in recruiting staff, purchasing equipment, developing programs and promotional material, preparing its annual report, renovating premises and providing assistance to clients. The following briefly reviews the status of these activities at each centre as of the end of October, 1983.

a) Ontario Centre for Microelectronics:

The centre has 32 staff either on a permanent or a seconded basis from industry and academic institutions. A CAD system and state-of-the art engineering software and hardware equipment have been installed. Seventy-five proposals have been prepared for product and chip designs and systems analysis and 14 contracts have been signed for product design, feasibility studies and chip design.

Activities in the promotional and marketing area include the development of an audiovisual presentation, an information kit, a marketing survey of microelectronics awareness sent to 2,700 companies across Ontario, exhibits in various trade shows, a bimonthly newsletter sent to 8,400 recipients per issue and extensive media coverage. Thirty-three overview seminars and technical training courses have been conducted with a total of 700 participants across the province. Three "industry days" provided an opportunity for almost 500 participants to tour the operations at the centre.

b) Ontario Centre for Advanced Manufacturing - CAD/CAM and Robotics:

The centres have a total of 40 permanent or seconded staff. A major tender for the purchase of CAD/CAM and robotic equipment was issued in the spring of 1983. The Robotics Centre has purchased eight industrial robots, and applications demonstrations for each robot have been developed. The CAD/CAM Centre has purchased six work stations, the central computer and two stand-alone systems and associated software. Evaluation of proposals with vendors is continuing on the remaining technical equipment. The majority of the CAD/CAM equipment will be installed by late winter. It will be used for staff training and demonstrations.

Forty-one proposals and 18 contracts for both centres have been signed, ranging from robotic applications to manufacturing processes, to CAD/CAM feasibility studies, to technical seminars for companies and colleges.

A demonstration booth has been developed and exhibited at major CAD/CAM and robotics expositions. The two centres have jointly held 10 workshops and seminars, with more than 200 participants. Both centres are currently developing a series of seminars ranging from the introductory level to the technical level. In addition, special industry specific seminars have been jointly sponsored with such groups as the Welding Institute of Canada. A three-day open house held at the Robotics Centre in October was attended by almost 3,000. Plans are under way for a major industry week at the CAD/CAM Centre in March, 1984. Other marketing activities have included public speaking, tours of the centres and media coverage.

c) Ontario Centre for Automotive Parts Technology:

The centre has 18 staff to date. Six contracts for productivity improvement are in progress and one technology development contract has been signed. Many proposals are currently under consideration. A full range of seminars, supplier/buyer liaison programs and training programs is being offered by the centre. A questionnaire has been distributed industry wide to assess the current state of technology. The centre is developing specialized training seminars in areas such as quick-die-change, just-in-time inventory, flexible management systems, statistical process control, and quality control circles for industry and educational use.

d) Ontario Centre for Resource Machinery Technology:

Eleven staff have been hired to date. Two projects have been approved and 57 proposals are being reviewed. Two marketing surveys to identify forestry and mining equipment produced and industry needs are being carried out. A seminar to identify mining equipment needs is being run. Other seminars will include patent applications. The centre is currently assessing priority market opportunities for the Ontario industry.

e) Ontario Centre for Farm Machinery and Food Processing Technology:

Five staff have been hired and recruitment efforts are continuing to hire the remaining staff. Several projects are being reviewed. Computerized equipment has been installed and information searches are being carried out.

E. Implementation Issues Related to the Technology Centres

The following will examine specific issues related to the implementation of the mandates of the Technology Centres.

a) Government and Technology Centres Relationships:

There are problems associated with attempts to develop cooperative ventures between the government and the private sector. These include distrust of the latter by the former and the bureaucracy that inevitably accompanies government involvement.

In establishing the Technology Centres, these problems were recognized by the government. Specific steps were taken. as indicated earlier, to ensure that the centres are operated by the private sector. In turn, recognition of the need for public accountability of government expenditure has been achieved through memoranda of understanding between the minister of Industry and Trade and chairmen of the boards and through general administrative and financial guidelines. In developing administrative and financial controls over the centres, the objective of the government has been to ensure their business-like development so that the government could concentrate on the strategic issues that need to be addressed and the centres could concentrate on meeting the needs of industry.

The Technology Centres demonstrate that it is possible for constructive results to be achieved through a cooperative and mutual relationship between the government and the private sector. The success of this relationship is considered to be one of the most important by-products of this program. This is particularly so given the exemplary experiences of other countries to forge cooperative relationships to maximize resources, as discussed in Chapter 1.

In addition to establishing a supportive and constructive relationship with each centre, one of the major functions of the Technology Centres Unit is to ensure the effective utilization of resources through the development of adequate coordination and linkages between the centres. The objective is to foster and maintain the cohesiveness of a technology program. While each centre operates within its own mandated sphere of influence, with its own programs and objectives, there are broader philosophical and practical reasons for ensuring that activities are carried out within the context of an overall government-sponsored technology program.

From a philosophical viewpoint, it is felt that the whole is greater than the sum of the individual parts in conveying the government's overall objective to assist industry to adopt technology. Further, the maximum utilization of limited resources is only accomplished if services and programs are not duplicated.

The need to ensure coordination is a very real consideration from a practical viewpoint. For example, similar clients may approach several centres and require joint assistance: the three industry-related centres have a need to keep abreast of state-of-the-art developments and applications related to the three technology-based centres; training seminars and workshops need to be coordinated to meet the needs of industry associations, labour groups and clients.

To accomplish the objective of a coordinated program, a council of presidents was established to resolve areas of mutual concern and to advise the government on policies and industry needs. Regular staff meetings at the marketing, administrative and information service levels are also ongoing. In addition, a coordinated information system on planned activities, seminars and workshops to link the centres, IDEA Corporation and the ministry is being established.

Each centre is responsible for the development and delivery of its own marketing and awareness campaigns. These are specifically oriented toward the markets that they are trying to reach. The Technology Centres Unit plays a coordinating role to ensure that conflicts and duplication do not take place and to encourage joint programs where feasible. As well, the Technology Centre Unit ensures that the centres do not contravene government policies.

In addition to the key target sectors defined by the centres, the Technology Centres Unit, in cooperation with BILD, has undertaken an umbrella campaign to promote the centres as a comprehensive program responding to the technological requirements of industry.

b) Evaluation of the Technology Centres:

The effectiveness of the centres will be evaluated on a regular basis to ensure they are appropriately serving their clientele and meeting their mandate. To accomplish this, the Technology Centres Unit, in cooperation with the centres, is establishing criteria on which the centres can be effectively assessed. The criteria will include types of client groups served, client results in terms of improved productivity and cost effectiveness, number of industrial applications, contracts and revenue generated by the centres.

The centres are also encouraged to carry out internal assessments on a regular basis and to review the delivery of each program against the targets set out in their business plan. To this end, each centre is collecting data on its activities and following up with clients to find out whether advice on equipment applications or new management techniques have been implemented and what the results are. These case studies will serve as examples to assist other manufacturers with the

introduction of technology to their operations. Further, they provide comprehensive background information to assist the government in assessing and modifing its own programs to reflect the needs of industry.

In addition to the informal evaluation mechanisms, the Technology Centres Act requires that an annual report on the affairs of each centre be tabled by the minister of Industry and Trade in the legislature by the end of September and that an annual budget be submitted to BILD. Every second annual report is required to include an evaluation of whether or not the centre should remain in existence.

c) Mandates of the Technology Centres:

At this stage, certain assumptions are being made with respect to the mandates of the Technology Centres. The specific mandates of the centres approved by cabinet in terms of their areas of concentration, self-financing objectives and applications as opposed to research orientation have been described earlier. Beyond this, it has been assumed that the centres must be results oriented. Therefore, they do not have a policy oriented function. While the centres serve as an important source of data and information related to technology transfer and industry sector needs, which will no doubt influence government policy, they are not intended to undertake activities in a larger policy development context.

The mandate of the centres is to assist secondary manufacturers to become more competitive. It is currently the view of the Technology Centres Unit that to use the expertise in the centres as a policy research and analysis resource or as a coordinating mechanism across government or accredited institutions is to greatly detract from their ability of being businesslike. However, even within this restrictive context it is possible to envisage that the question may arise over the

role of the centres in this area. While there is no doubt that policies need to be developed in many areas to provide a supportive environment within which industry can profit from the opportunities presented by technology, this is felt to be the role of the government, with input from the centres where appropriate.

In time, as the needs of industry change and as new technologies emerge, the mandates of some of the centres may need to be broadened or refocused. For example, the integration of computers in manufacturing is recognized by having one president and one board of directors for both the CAD/CAM and Robotics Centres. However, it is possible that the focus of the Ontario Centre for Advanced Manufacturing may need to be broadened to include the whole area of hard automation and flexible manufacturing, the integration of the automated office with the automated factory, and the resultant impact on management systems and organizations. It follows that the mandate may need to be expanded to include office automation in non-manufacturing situations.

d) Development of Linkages with Other Bodies:

To ensure the maximum use of resources, it is crucial that effective linkages be developed with both internal and external bodies. As indicated in Chapter 4, there is a wide variety of other provincial and federal programs to supplement and complement the activities of the Technology Centres. In addition, the many industrial associations labour organizations, private research institutions, colleges and universities, and companies involved in technology all have a role to play. The Technology Centres will be working closely with colleges and universities and industry to foster an awareness of future skills and to assist in meeting industry needs. For example, a project carried out by one of the centres in cooperation with a community college might form the

foundation of a TIBI program. As well, the centres serve as a resource to students and industry in terms of both expertise and equipment.

The Technology Centres Unit currently provides a catalytic role in terms of linking other technology-related activities within the Ontario government to the Technology Centres. Its role includes increasing the awareness of other agencies and ministries with respect to the activities of the centres, seeking out areas of mutual interest and benefit, and ensuring that potential duplication of resources is averted.

It has become evident through these efforts to establish linkages that there is generally a need for improved coordination in technological areas across the government. In discussions with universities, research institutes and the private sector, it is also apparent that there is a need for greater coordination of research and development efforts, as well as the sharing of results for potential application in other fields and for commercial opportunities. While efforts will continue by the Technology Centres Unit and the centres, as well as IDEA Corporation, to establish linkages and identify potential opportunities for industry, the effort required would appear to be greater than their current mandates allow.

3. IDEA CORPORATION

A. Establishment

IDEA Corporation is a central element in the government's support of technology to enhance the long-term economic growth and employment prospects of Ontario.

The Act to Establish a Corporation to Promote Innovation Development for Employment Advancement created IDEA Corporation as a Crown agency on October 30, 1981. The corporation reports to the Minister of Industry and Trade. On March 16, 1982, the board of directors of IDEA Corporation was appointed from industry, university, labour and government sectors.

B. BILD Approval of Financial Plan

Unlike the Technology Centres, IDEA Corporation was created and its board of directors appointed prior to the development of a business plan. The board recruited a president, whose first major task was to justify, through a financial plan, the budgetary requirements of the corporation for BILD approval.

The business plan for the corporation received BILD approval in January, 1983. The corporation has been provided with $107 million over five years. The five-year financial plan is summarized in Table 5-1. IDEA Corporation is expected to conduct its affairs like any other commercial operation.

TABLE 5-1

IDEA CORPORATION

Financial Summary

($000s)

	1982-83 Actual	1983-84 Approved	1984-85 Forecast	1985-86 Forecast	1986-87 Forecast	Total
Operating	1,700	4,000	4,400	3,500	2,400	16,000
Five Technology Funds	10,000	31,000	20,000	4,000	-	65,000
IDEA Innovation Fund	-	4,000	3,000	3,000	3,000	13,000
Research Investment Fund	-	4,000	3,000	3,000	3,000	13,000
						107,000

C. Mandate of IDEA Corporation

The broad mandate of IDEA Corporation is to:

- promote the process of technological innovation from all sources, including universities, research groups, individual inventors and private corporations, and from all regions of the province:
- bring the research capabilities of the public sector together with the commercial and industrial sector:
- enhance growth and employment prospects of the Ontario economy, both on a province-wide and a regional basis.

The essential purpose of IDEA Corporation is to advance the process of commercializing technology.

The major functions of IDEA Corporation - venture capital, technology brokerage and advising the government on issues related to technological innovation - are described here.

a) Venture Capital:

i) Technology Funds:

The major portion of the government's funding to IDEA Corporation, $65 million, has been allocated to five Technology Funds. These funds work through joint ventures with private sector partners and invest in projects in five broad technological sectors. The five technology funds that have been incorporated are:

- IDEA Biological and Medical Technology:
- IDEA Chemical and Process Technology:
- IDEA Information Technology:
- IDEA Machine and Automation Technology:
- IDEA Microelectronics.

These funds provide a unique opportunity for cooperation between the public sector, represented by IDEA Corporation, and the private sector, represented by investment from such sources as pension funds and insurance companies. The IDEA Corporation funds work with individual inventors, universities, research centres, companies of any size, and with other investment funds. It is expected that the government's seed funding may lever further private sector funds to incorporate in joint projects. Each of these funds has been seeded with a total of $13 million over five years.

The corporation prefers to be an equity investor and expects to share in the financial returns of any project. The basis for calculating the return on investment is negotiated at the outset of each venture. As the sponsor for each fund, IDEA Corporation will seek out innovations that can be developed and commercialized in Ontario. The funds invest in new

products and processes in each of their designated areas. Investments are made at any and all stages of development, from initial concept or design of a prototype to expansion of markets for innovative products of established companies.

The funds are described briefly below in terms of their possible areas of investment.

Biological and Medical Technology Fund:

- agricultural technology, aquaculture technology, biological engineering applications, environmental protection technology, medical diagnostics, medical equipment and instruments, pharmaceutical products and silviculture technology.

Chemical and Process Technology Fund:

- agricultural chemicals, chemical engineering, environmental protection, food production and processing, metallurgical engineering, mineral extraction, new materials, pulp and paper production and waste management.

Information Technology Fund:

- artificial intelligence, CAD/CAM systems, computer hardware, computer software development and computer languages, courseware and computer-aided learning systems, data processing, storage and transmission, fibre optics, telecommunications equipment and voice recognition systems.

Machine and Automation Technology Fund:

- CAD/CAM, industrial automation, machine development, materials handling, mechanical and electrical engineering, productivity

improvement systems, robotics, sensing systems and transportation.

Microelectronics Fund:

- electronic components, instrumentation, integrated circuits, laser and infrared equipment, microelectronic control systems and software, photovoltaic devices, semiconductors and sensors.

Each fund will consider projects that offer innovative technology, above-average commercial potential, as measured against technological, marketing and financial criteria, and enhancement of Ontario's economy. Each fund functions as an independent venture capital firm, with its own board of directors overseeing the work of expert management teams. Wherever possible, the fund invests through joint ventures with outside investors.

ii) Subsidiary Funds:

The corporation also has incorporated two wholly owned subsidiary funds, the IDEA Research Investment Fund and the IDEA Innovation Fund. These funds are capitalized at $13 million each, to be drawn down over a period of four years.

The IDEA Research Investment Fund invests in technological innovation at its earliest stages, with the aim of taking it to the point where it is commercially viable. IDEA Corporation will not give research grants, but rather will take an equity position in its projects. The corporation will also assist in the commercial exploitation of successful projects.

The IDEA Innovation Fund is an internally funded vehicle established to invest in a broad range of ventures and projects and to

permit flexibility in the scope and timing of investments. The fund would be likely to earn returns that are, on average, lower than the Technology Funds, but would compensate by striving to find investments with long-run pay-off for the province as a whole, if not the fund directly.

b) Technology Brokerage Function:

One of the functions of IDEA Corporation is to act as a catalyst in locating commercial opportunities for new technologies in return for fees or royalties. The IDEA Corporation Act empowers the corporation to "acquire, develop and deal in industrial property, licenses, inventions and processes and the royalties and benefits following therefrom." IDEA Corporation will also seek to license innovations from around the world to Ontario companies for further development, production and marketing. IDEA regards this process of technology brokerage as a natural complement to its venture capital activities.

c) Policy Advice:

In view of its direct participation in developing new technologies, IDEA Corporation will advise the Ontario government on technological innovation and its social impact. It will conduct studies to analyze the needs and opportunities of the innovation process and recommend public policy options to stimulate innovation. IDEA Corporation will liaise with other ministries, agencies, colleges and universities, and the Technology Centres and will also perform a public education role.

d) Unique Features of IDEA Corporation:

IDEA Corporation has some interesting features and is, in a sense, a new experiment. In the first instance, the government is putting

a significant sum of money into syndicated funds, recognizing that the majority of the money in each of the funds will be invested by the private sector. Therefore, the individual investment decisions will be taken by the boards of the individual funds. This means that the majority of the shareholders is making investment decisions. The funds will be formed under unanimous shareholders' agreements stating what sort of investments should be made and where these investments should be made. IDEA Corporation moneys will be spent on technology in Ontario and in areas that will be wealth and job-creating for Ontario. However, within these parameters, the individual investment decisions will be made by the boards, the majority of whose members will be representative of the private sector.

The second feature relates to the in-house marketing, financial and technological capabilities within IDEA Corporation. This is unusual for venture capital funds, which normally consist of a small number of fund managers who contract out any feasibility studies. While feasibility studies may still be contracted out by IDEA Corporation, they will be done under the overall control of people who are expert and knowledgeable in their specific disciplines.

It is hoped that through this approach first-class projects will be attracted to IDEA Corporation and that the corporation itself will assist in the packaging of attractive investment opportunities.

The third feature is the linkage of the Research Investment Fund to the five Technology Funds. This will enable the researcher or inventor to be exposed to the realities of commercialization at an early stage. At the same time it offers to the universities IDEA's commercial perspective on research under way on their campuses.

D. Start-up Activities of IDEA Corporation

The corporation has completed the recruitment of its senior management team, and is completing the recruitment of its investment analysts and management staff for the funds. By November, 1983, 31 staff had been recruited.

By November 1, 1983, about 300 proposals had been received by IDEA Corporation. With regard to fund syndications, one deal has been closed with a venture fund management team to form and manage a joint venture between IDEA Machine and Automation Technology Fund Inc. and private sector investors. Negotiations are under way for two other fund syndications, which will involve commitments of $15 million and $7 million respectively from IDEA and, with Ansam Synergistic Technologies Ltd., should lead to a total pool of $97 million by early 1984. The purpose of the money is to finance technology ventures in industrial automation.

Under IDEA Research Investment Fund Inc., investments have been made at Queen's University for a project involving potential commercial applications in treatment of congestive heart failure and at the University of Western Ontario for research into methods to synthesize a group of compounds for selectively depositing metals in electronic circuit manufacture. In return for investing in this research, IDEA will receive future royalty rights from commercial licensing following investment payout.

Under IDEA Innovation Fund Inc., investments have been made in Ferritronics Limited to assist in product development, in partnership with a private venture capital company. This company has developed innovative radio signaling equipment including tone and data systems for hand-held transceivers, digital voice scrambling and signaling modules. Investments have also been made in RMS Industrial Controls Inc. to finance new product

design and business development. This company is expanding its operations in Ontario and will produce RF microwave thin film components.

E. **Implementation Issues Related to IDEA Corporation**

In view of the decision to syndicate the majority of the funds, IDEA Corporation has had to concentrate most of its attention on finding appropriate partners for these funds. While IDEA Corporation has received many requests for assistance and investment, it has not been able to make investment decisions until the appropriate funds are syndicated and the private sector can be involved in such decisions. It is taking time to negotiate appropriate agreements and to ensure that they meet the needs of the interested parties. It is essential that good groundwork is laid so that any investment decisions taken are in the context of total agreement as to the objectives and the relationships of the partners. It is, therefore, too early to comment on the effectiveness of IDEA Corporation in filling the venture capital aspect of its mandate.

Once the funds have been syndicated, the issue for IDEA Corporation and its partners will be similar to those of the classic venture capital organization: to ensure that the spread of risk is sufficient and that the investing decisions provide a return on investment that demonstrates success and maintains the credibility of the operation.

It is apparent, based on the initial year of operation, that the running of the venture capital aspect of the business consumes a significant portion of management's time. Once the investments have been made, projects will require ongoing information, management support and control for the foreseeable future.

4. OTHER TECHNOLOGY ACTIVITIES WITHIN THE ONTARIO GOVERNMENT

Currently, there is a wide range of programs and policies throughout the Ontario government directed to the support and development of technology. These range from direct technological innovation, product development and marketing through various institutions and corporations to sectoral initiatives through BILD and individual ministries. The ultimate goal of these programs is sustained economic growth for Ontario.

An inventory of many of the technology-related activities within the Ontario government was prepared as briefing material for the Canada Tomorrow Conference in Ottawa on November 7-9, 1983. In addition, the "Inventory and Review of Canada-Ontario Science and Technology Programming" referred to in Chapter 4 supplies a comprehensive listing of Ontario's activities. While this material provides a more complete discussion, it is considered worthwhile to give an indication of the diverse nature and the breadth of activities supported by the Ontario government. In this context, a brief listing of various technology activities by selected ministries is provided.

BILD

Technology Initiatives

- funding commitments of $480 million, directed to high-technology initiatives, R&D and innovation in the areas of electricity, transportation, resources, technology and people.

Management Board of Cabinet

Management Technology Branch

- develops policies and guidelines governing the acquisition of computer hardware.

Deputy Ministers' Technology Directions Committee

- oversees the implementation of technology within the Ontario public service.

Ministry of Community and Social Services

Applied Program Technology Unit

- provides policy research and impact analysis of technological developments on ministry programs and client services.

Five-Year Management Information Strategic Plan

- uses up-to-date technologies and methodologies to support consistent, relatable data bases across the ministry.

Ministry of Natural Resources

Mineral Exploration Program

- maximum grant and/or tax credit of $500,000 toward mineral exploration in designated areas.

Forest Biomass Institute

- develops plants and trees for industrial use in conjunction with the pulp and paper and forestry industries.

Ontario Centre for Remote Sensing

- undertakes research and development in the digital analysis of satellite data and airborne remote sensing;

- operates a technology transfer program with the private sector educational institutions, and an information exchange program with other governments and interested parties.

Ministry of the Environment

Environmental Management Program

- controls the pollution of air and water and the application of pesticides, and manages community and industrial wastes.

Laboratories

- measure a wide range of microorganisms and chemical substances in a manner that competes with the world's leading laboratories.

Ministry of Energy

Ontario Energy Corporation

- administers, in conjunction with the University of Waterloo, the new Energy Technology Business Assessment Service to evaluate and partially develop unpatented energy ideas and inventions.

- Energy Technology Investment Group holds investments in the energy supply fuel substitution and energy management areas.

Bruce Energy Centre

- undertakes to turn the steam generated by the Douglas Point nuclear station into a source of electrical energy for surrounding industrial and agricultural consumers.

Institute for Hydrogen Systems

- engages in hydrogen research, development, demonstration and commercialization projects such as fuel cells and advanced hydrogen production and storage technologies.

Fusion Fuel Technology Program

- investigates alternate fuels and energy sources for sale to international fusion research projects as part of a long-term research project in cooperation with Ontario Hydro, the National Research Council and BILD.

Ministry of Education/Colleges and Universities

Training in Business and Industry Program

- provides funding for training programs operated either in-house by businesses or as accredited courses at colleges of applied arts and technology to develop new skills required by advanced technology industries.

Funding Advanced Technology Installations at CAATS

- provides funding to the colleges to upgrade their equipment and facilities for training in the areas of microelectronics, CAD/CAM, robotics, automation, biotechnology and petrochemical production industries.

Microcomputers for Educational Use in Ontario Schools

- $10 million purchase from CEMCORP of "Icon" educational computer system for subsidized resale to Ontario school boards.

Educational Applications of Telidon

- establishes a 21,000-page data bank including the ministry's Student Guidance Information System;
- setting up a 100-terminal Telidon network in schools, youth centres and libraries to evaluate effectiveness of videotex systems.

Ministry of the Solicitor-General

Ontario Provincial Police Telecommunications Branch

- developing a voice communication system for the OPP designed to accommodate data and cover 725,197 square kilometres.

Ministry of Transportation and Communications

Pilot Program on "Office of the Future"

- currently being implemented within various ministries including Transportation and Communications, Environment, Labour, Health, and Consumer and Commercial Relations.

Transportation, Technology and Energy Branch

- involved in research and development related specifically to traffic management as well as the transfer of technology developed in the branch to industry-based services;

- the Fibre Optics Communications Program is undertaking work on the use of fibre optics technology to replace the present cable system method of communication on Ontario highways.

Urban Transportation Development Centre

- specializes in the development of high-technology automated transit systems with intermediate capacity.

Ministry of Government Services

Video and Audio Teleconferencing System

- aimed at reducing energy consumption and improving government effectiveness. A fibre optics link has been established.

Ministry of Industry and Trade

Program to Encourage Product and Process Innovation (PEPPI)

- encourages the development of new products or processes by providing the inventor or small business with 75 percent of eligible costs up to a maximum of $10,000 to build a prototype of an invention to prove its feasibility.

Product Development Management Program (PDMP)

- provides up to 50 percent of costs to a maximum of $20,000 to manufacturers who lack certain expertise in new product development, particularly in industrial and/or engineering design, who require consulting services for high volume production of durable goods.

Small Business Industry Technology Program (SBITP)

- provides from 75 percent of costs to a maximum of $15,000 to manufacturers for new product development where a significant advance in the areas of technology and engineering will lead to a reduction in product obsolescence.

Ontario Development Corporation (ODC)

- provides selective financial assistance, in conjunction with conventional sources or other programs, through loan guarantees, term loans or export support lines of credit, for the establishment and expansion of secondary manufacturing industries.

Ontario Research Foundation

- undertakes a wide variety of industrial research and development projects on a non-profit contract basis.

Ministry of Health

High-Technology Initiatives

- diagnosis (CT Scan, digital radiography):
- genetic screening;
- lasers (microsurgery, fetal surgery);
- remote-emergency diagnosis:
- robotics (biohazard containment).

While this by no means provides an exhaustive list of technology-related activities in the Ontario government, it does provide an overview of the scope of activities. There is a need for greater coordination between related activities under different sponsors, than currently exists, in the interests of maximizing resources and minimizing duplication.

CHAPTER 6

TECHNOLOGY: IMPLICATIONS AND STRATEGIC CONSIDERATIONS FOR ONTARIO

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CHAPTER 6

TECHNOLOGY: IMPLICATIONS AND STRATEGIC CONSIDERATIONS FOR ONTARIO

1. INTRODUCTION

This chapter highlights the major implications arising from the discussions in the previous chapters and identifies strategic considerations for Ontario. It is not intended to pursue every implication arising from the paper. The purpose is to focus attention on overall implications for the province of Ontario. Specific solutions are not suggested. Rather, issues are identified and alternatives discussed in general. It is recognized that at the more detailed levels, where expert knowledge is required, further analysis will have to be undertaken before the appropriate solutions can be identified.

The implications and considerations will be reviewed under broad themes that have emerged from the previous chapters. However, there will be obvious areas of overlap between the technological, economic and management implications.

Having said this, a further message emerges. In reviewing other countries' activities in the development of technology, it is apparent that enormous investments are required. Japan and the United States, even with their different approaches toward cooperation between the private and public sectors, both spread their risks by investing time and money in a wide range of technologies and alternative solutions. Thus, if there are six alternatives to a specific problem, the Japanese and the Americans will probably have processes that will enable them to invest in all six. If only one succeeds, the failures are seen as part of the investment in that one success.

Given the level of resources required, Ontario cannot follow such an approach. Ontario probably has to learn to survive in an expert technological world through a mix of licensing technology for production and application, identifying its strengths and then assisting in filling niche areas of opportunity.

Finally, the discussions in this chapter are in the context of an appropriate role for government. This is addressed at length in Chapter 7. The basic assumption is that the government should act as a catalyst and a coordinator, but not in an interventionist style. Therefore, behind all the strategic considerations is the assumption that if the government can provide the right environment, then the private sector can take advantage of the opportunities created by such an environment.

2. TECHNOLOGY IMPLICATIONS

Chapter 1 provided a broad overview of selected technological developments and opportunities, support in other countries, and Ontario's current position. The technology implications discussed in this section raise some possible niche areas based on a preliminary review. In this sense a level of detail is discussed. However, the niche recommendations are largely in pursuit of broader goals. For example, the discussion on the question of chip production is not one about chip production per se, but rather about supporting the development of a healthy electronics industry and protecting secondary manufacturers against the possibility of supply shortages of what may become a basic commodity for manufacture.

A. Microelectronics

Several overriding conclusions can be reached from the discussion of microelectronics in Chapter 1:

- There has been a rapid increase in the capability of the chip, which continues to accelerate with new technological breakthroughs.
- This capability is being utilized to create components of increasing functionality, reliability, versatility and processing speed that occupy less space, are lighter and are more energy efficient.
- These components are dramatically decreasing in price, as the manufacturing volume increases, so that cost-effective applications in the office, home, industry and communications will continue to emerge.
- Companies that have profited from microelectronics have sought world market volumes, highly automated manufacturing and

highly skilled innovative research talent.

- The use of the chip in new products and manufacturing processes offers opportunities for product innovation and improved product quality as well as increased productivity. Microelectronics will increasingly be a driving force in the ability of secondary manufacturers to remain competitive.
- Canada, with a few outstanding exceptions, has very little capability in the design, manufacturing and marketing of state-of-the-art components. There is no Canadian manufacturer of a broad range of semiconductor devices for the general electronics market. This market is, therefore, almost totally dependent on importing chips. Canada does have an excellent capability in the application of components to the information and communications industries, where many world market niche opportunities are being successfully exploited.

a) Implications:

There are a number of major implications for Ontario suggested in the review of microelectronic developments on an international basis. First, it is evident that there is enormous growth potential for makers of microelectronics in Ontario, given the projected demand and range of applications of microelectronics across all sectors. However, in view of the rapid pace of technical developments, unless electronic companies can keep up to date with these developments and foster niche areas of expertise, they will be unable to compete with foreign producers.

Second, it is unquestionable that secondary manufacturers in Ontario need to apply microelectronics to their products and processes if they are to remain competitive. Given that the chip is the heart of

microelectronic developments, the future competitiveness of many manufacturers in Ontario depends on their ability to obtain a steady supply of this basic commodity.

b) Strategic Considerations:

Arising from these implications are several strategic considerations for Ontario. One is the extent to which the government needs to further support the development of a healthy silicon-based electronics industry, as well as the application of microelectronics by secondary manufacturers. Initiatives such as direct funding support to microelectronic companies and the establishment of the Ontario Centre for Microelectronics have been major incentives to assist industry in the exploitation and use of advanced technology.

A second consideration is the need to ensure that the electronics industry and existing and potential users have access to state-of-the-art semiconductor developments. This is particularly so given the forecasts noted in Chapter 1 regarding protectionist technology developments in other countries and worldwide shortages in the supply of chips.

To be limited to importing foreign technology, if and when it becomes commercially available, will never allow major Canadian products to achieve world leadership. Within a few years, systems such as computers, communication terminals, test equipment and CAD/CAM will be designed directly onto silicon and, therefore, require the joint developments of systems concepts, silicon technology and design methods. Only Northern Telecom and Mitel currently have the benefits of simultaneous systems and chip developments in Canada. Their success demonstrates the need for such capabilities to be developed by other companies in Canada in order for them to remain competitive.

Several initiatives to establish a silicon processing and development capability in Canada have been reported. The Alberta Research Council has proposed a cooperative effort by industries, universities and government to establish a microchip custom design and manufacturing industry in Alberta. The objective is to support the growth of high-technology industries and develop a niche in the international chip design and fabrication industry for the purpose of marketing chips in Canada and to other countries. A report prepared by the council stated that the establishment of a silicon capability in Canada is essential to reduce our dependence on importing entire systems, given that trade barriers in microelectronics are being constructed by other countries.

British Columbia announced in September, 1983, a major initiative with the federal government for a $50 million integrated circuit assembly plant. The plant will be built by Dynateck Electronics Corporation and will be in operation by year end.

Canadian universities from coast to coast have made a joint proposal to the National Sciences and Engineering Research Council that, if implemented, would greatly enhance the Canadian educational capability in silicon processing. A cooperative design network has already been approved.

While there are reported to be several other entrepreneurial efforts to start chip manufacturing and design facilities in Canada, the chances for the start and success of such endeavours are undefined at this time. One of the factors related to the location of any such chip foundry is that it would be a drawing card for high-technology industries and spin-off activities that promise wealth generation and employment potential for a province.

In view of the billion-dollar battle for world dominance in semiconductors being waged by Japan and the United States, any initiative

in Canada may need to focus on selective competitive niches in this industry. Whatever the niche, fierce competition will be faced from other countries. The issue, however, may be that Canada cannot afford to be deterred.

c) Action Plan:

Several issues need to be considered in addressing the strategic consideration of how to support the development of a competitive silicon-based electronics industry in Ontario by ensuring access to state-of-the-art developments.

First, it is conceivable that the availability and ownership of state-of-the-art chips may need to be viewed as a basic commodity in the information age on which the competitiveness of industry is becoming increasingly dependent. Just as oil has been a critical commodity in the past, chips may be the driving fuel behind competitiveness in the future. Therefore, government support for high-risk and expensive R&D to exploit microelectronics in Ontario may need to be viewed as a long-term investment in the future of the electronics industry and secondary manufacturers. Although Canada does not lack for entrepreneurship in certain niches, the area of custom chip design and manufacture may be one where government support may be needed.

Second, the creation of a competitive silicon-based electronics industry requires a well defined, cooperative strategy between industry, government and university sectors and a commitment to its execution.

Ontario has significant advantages for the development of a silicon-based industry. There is a strong knowledge base in Ontario's universities. The two companies with major semiconductor capabilities, Mitel and Northern Telecom, are both Ontario based. Of significance are the skills of smaller but also highly talented companies like Linear Technology, Siltronics and MOSAID. The world population of "silicon

experts" is very small, possibly no more than 2,000 people. Ontario has achieved a reputation enabling it to attract world-class experts, without which a true silicon capability would be an impossibility. This is an excellent start toward a silicon environment, but it may still be below a regenerative threshold level capable of developing the required technological critical mass.

Entrepreneurial proposals should be encouraged and constructively reviewed. Start-up assistance may need to be provided by the government, where appropriate. Continued and increased support for educational institutions should be provided, and cooperative undertakings between and among universities and industry should be actively encouraged.

Third, there is a need to investigate the issues that are critical to the advancement of the information industry. One key issue is the extent to which secondary manufacturers in Ontario may be vulnerable to a shortage in the supply of chips. Based on this preliminary industrial intelligence, the various options for securing a supply of chips to Ontario industry should be reviewed. Options could range from developing cooperative arrangements with potential silicon development initiatives in other provinces, to arranging with Mitel or Northern Telecom to use their internal foundry if spare capacity is available, to assisting Ontario manufacturers in securing arrangements with foreign producers of chips and licensing technology, to reviewing the feasibility of establishing a silicon processing and manufacturing capability in Ontario. In view of the required high capital cost, sales volume, and the critical mass of technical and research expertise to support a silicon capability, the last option would require thorough investigation.

It is not possible until further investigation has been undertaken to recommend a more concrete action than the urgent need to review each of these options as well as other appropriate means for the

government to support the microelectronics industry. Some of these options may need to be considered by the government in conjunction with the proposed action plans related to the issue of working capital to finance technological recapitalization. This is an area where the federal and provincial governments and industry need to collaborate and transcend regionalism. Any design and fabrication facilities built in Canada cannot survive in the Canadian market alone. Finding our niche is only half the challenge. Competing on an international basis will be the real test. As other countries have shown, this requires a national purpose and commitment.

B. Computers

Software Industry: Opportunities for Ontario

a) Implications:

Given the trend in industrialized nations toward a decrease in the manufacturing sector and an increase in the service sector, it is clear that a source of future wealth and employment is in the information area. One such niche area of opportunity for software companies is the developing of customized software for the service sectors.

International marketing is becoming increasingly necessary to attract vendor clients and to establish worldwide competitiveness.

b) Strategic Considerations:

Software advances will be a driving force in the computer industry during the next decade compared to the hardware side. Whereas several major foreign companies, most notably IBM, appear to have dominated the hardware market and will be setting the industry standards, the software industry remains more open for new entrants to establish a

competitive foothold. The extent to which the Ontario government has a role in supporting a competitive software industry in Ontario requires an analysis of its constraints and the competitive advantages.

The constraints appear to be largely conceptual. Software is an intangible product, operating under different rules in some cases from those that apply to manufactured products. Many people do not understand what software is, as it is primarily an intellectual activity, or how to use it for increased productivity.

Obtaining adequate financing from the private and public sectors for the research, design, packaging, marketing and distribution of products by software companies is extremely difficult. This may be due in part to the ephemeral nature of software. Current government programs may need to be reviewed to determine whether to encourage the development and marketing of software. Initially, it appears that government programs are lacking, are difficult to apply or provide a disincentive compared to the extent of support for the hardware side. For this reason, the federal government has recently introduced a major incentive by restoring the 100 percent write-off on software used under license by industry.

There may be other instances where changes in funding programs or in tax regulations are required to promote not only software R&D, but also the marketing and distribution aspects, where many small- and medium-size companies are at a disadvantage in Canada because of the lack of appropriate channels. Concern has been expressed about the criteria for defining how software projects constitute scientific research under the Income Tax Act. International marketing should be a particular concern to Canadian software companies, given the size of the Canadian market. For example, the Canadian domestic market is about one-quarter the size of California's market.

One of the competitive advantages for Ontario is the availability of technical expertise in both the industry and the academic

sectors. Many computer experts have stated that software is an area where Ontario can take a leadership role because of the availability of engineers and technicians with the required academic skills. Prospects that make joint use of resources and experience in the private sector and in universities should be actively encouraged and supported.

The constraints and advantages of developing and marketing software for global markets versus a niche strategy in specialized areas need to be explored. A further consideration is to ensure appropriate software development to support our own service and manufacturing sectors. The trend in Canada towards an increase in the service sector points to the need to examine the components of an information industry, where our strengths and weaknesses lie and what opportunities there are for Ontario. This is an area where the government, in conjunction with industry, needs to develop a coherent understanding of the issues related to the information revolution. For example, one of the key issues is that if Ontario does not take the opportunity to develop support industries, such as software, to foster its information industry, it will be dependent on imports from other countries rather than creating export potential. The short run production orientation of many secondary manufacturers in Ontario underscores their need for specialized software development.

c) Action Plan:

One area for immediate action is a review of an appropriate role for the government of Ontario in supporting the growth of a competitive computer software industry and the marketing of its products. This should include an assessment of the software industry in Ontario and its competitive position: present constraints on software development and their impact on other industry and service sectors; potential niche areas of opportunity: and alternative strategies, including how the industry is

to be developed and its products marketed both domestically and internationally, and how associated R&D is to be pursued.

This is an obvious area for close consultation with the private sector and colleges and universities on how best the government could assist in focusing and supporting software development for marketing in Ontario and for export. Various mechanisms should be considered, from greater coordination among universities in software development, to closer liaison between universities and the private sector in applications and the training of software specialists, to financial assistance to companies for research, marketing and distribution, to establishment of a generic software development and applications centre.

Any review initiated by the Ontario government should also include an investigation of developments in software policy in other provinces and by the federal government.

C. Optoelectronics

a) Implications:

The discussion in Chapter 1 indicated that some Ontario optoelectronics companies, such as Northern Telecom and Lumonics, are among the first-rank producers in the world. It is essential in strategic terms that Ontario maintain, if not expand, these world-class production niches. There are at least five other major players on the international stage - two American and three Japanese - and others are almost surely poised to enter the first rank. Still others have consolidated strong positions in regional markets.

That special action may be required at some point to nurture our competitive position is suggested in Chapter 1 by the following factors: the rapid pace of change in optoelectronic technologies: the substantial

research and development programs of other leading producers: and the depth of commitment demonstrated by some other governments, especially Britain and Japan, in support of their optoelectronic industries.

A second set of implications arises from considering the potentially adverse impact of rapid optoelectronics development on Ontario suppliers of some mature technologies. One example is copper wiring, which, for reasons noted in Chapter 1, suffers from severe disadvantages compared to fibre optics for use in communications systems. The potential effects on Ontario copper producers, such as Inco and Falconbridge in Sudbury, need to be explored, especially with respect to the percentage of sales now directed to communications systems; how this fraction is expected to change during the next five years: the anticipated rate of substitution of fibre optics for copper: and the possible consequences for communities such as Sudbury that may be seriously affected.

b) Strategic Considerations and Action Plan:

Ontario is at a disadvantage in not having at its disposal the requisite in-depth technological and industrial intelligence needed to assess its strategic position in optoelectronics and to determine what responses, if any, that position demands. Accordingly, the Ontario government needs to acquire and maintain technological and industrial intelligence sufficient to define niches and identify what, if any, supportive actions may be needed to maintain and expand upon them.

For example, as an initial consideration, any government support should be based on knowledge of our current share of relevant market segments in the optoelectronics industries, as well as capital investment trends, trade positions and R&D initiatives. As regards Ontario companies, separately and collectively, this would include information on their share of the Canadian market, the U.S. market and the global market;

how those shares have changed during recent years: and, given their product positioning, what the consensus of expert opinion indicates regarding their future prospects and the appropriateness of individual corporate strategies in realizing those prospects. Action of this kind would also clarify where barriers to further development may arise. Such barriers might include, for example, research and development funding: capital financing: or a need for export promotion to boost global market shares, raise production volumes and reduce unit costs.

D. Biotechnology

a) Implications:

Biotechnology, in its current stage of development, is research intensive. Accordingly, a competitive premium can be expected from the development of a human resource base suitably organized to generate new products and processes.

An R&D infrastructure should be designed to promote the training and development of human resources, to build a solid base of new technology and to foster an environment conducive to industrial growth and prosperity. This can be accomplished, in part, by encouragement of university graduate and undergraduate programs in relevant applied sciences. Joint efforts in R&D could be facilitated by the creation of direct channels of communication between governments, universities and industry. The need for new industrial processes and systems can be met through an integrated on-the-job training approach. A coordinating group comprising representatives from industry, universities and government would be useful in ensuring that funding and R&D efforts are directed into those areas of specific opportunity for Ontario.

The discussion in Chapter 1 detailed the formidable nature of international competition. More than 40 countries have a biotechnology industry of one kind or another, with the United States, Japan, West Germany and the United Kingdom being the overall leaders worldwide. Competition is intense even within North America, as the staff levels and resource scope of companies within one sub-field of biotechnology suggest in Table 6-1.

TABLE 6-1

NORTH AMERICAN COMPANIES IN AGRICULTURAL BIOTECHNOLOGY

Companies	Scientific Staff* (APPROX)	Crop Species
United States		
Advanced Genetic Sciences	73	6
Agrigenetics	160	Over 20
BioTechnica International	20-25	3
Calgene	60	7
Cetus-Madison	30	7
DNA Plant Technology	40	4
International Plant Research Institute	60	10
Molecular Genetics	25	3
Native Plants	50	5-6
Phytogen	25-30	6
Plant Genetics	50	6
Sungene Technologies	40	5
Canada		
Allelix (1984)	15-20	1-2

* On agri-related activities.

The need for the careful selection of production niches is underscored by certain key conditions now prevalent in the industry: the technology is fluid, lead times to product development are frequently long and the international competition is fast.

b) Strategic Considerations:

Two major strategic considerations for Ontario following from these implications are:

- to create and maintain a research and development infrastructure in biotechnology;
- to focus the efforts of that infrastructure within areas that hold promise of international competitive success for Ontario producers.

The diversity and scope of the opportunities presented by new biotechnology are paralleled by the intensity of the competition internationally in terms of financial commitment, scientific talent, industrial participants and the lead time enjoyed by companies and institutions that have been targeting biotechnology for many years.

For this reason, it is essential that Ontario focus its biotechnology efforts on those areas where we have a realistic chance of becoming internationally competitive. Sectors that are likely to be more promising are those in which Canada or Ontario is a major world player and where, consequently, there is a well-developed infrastructure and some existing R&D activity.

One such example is the agricultural sector. The critical importance of agriculture to the vitality of Canada's and Ontario's economy, coupled with the relative strength of the Canadian research base in agricultural sciences, makes this a natural focus, particularly worthy of a concentrated effort by Ontario. Moreover, unlike the health care sector, the competitive factors in agriculture are not as overwhelming. This is a reflection of the greater involvement and research intensity in health care and the longer lead times required for commercialization of biotechnology in agriculture.

c) Action Plan:

It is proposed that the leading areas of biotechnology research be reviewed, and, if conditions warrant, action be taken immediately to anchor an Ontario presence in two ways:

- by focusing current efforts more effectively in order to create a critical mass of biotechnology R&D;
- by attracting more researchers to Ontario through such means as increased research funding and, for example, the establishment of university chairs in biotechnology.

E. Advanced Manufacturing Technology

a) Implications:

Two major implications arise from Chapter 1. The first concerns the opportunities presented by advanced manufacturing technology for Ontario's manufacturing industries to regain global compétitiveness. The other implication concerns management challenges posed in effectively capturing their competitive potential. These implications are discussed in Section 3, on economic implications, and Section 4, on management implications, in this chapter.

A further implication arises from Ontario's very limited presence in the market for advanced manufacturing equipment. Although, with the exception of Orcatech, Ontario does not produce CAD/CAM equipment to any significant degree, there are a number of manufacturers of peripheral equipment in the province. Some advantage might be gained were a greater number of makers of peripherals to link up with the larger, main-line CAD/CAM equipment producers.

F. Advanced Materials

The field of advanced materials is an excellent example of an emerging technology whose opportunities for Ontario are just beginning to be recognized. As with biotechnology, the work being done on many advanced materials is research-intensive, and lead times to widespread commercial production are frequently uncertain. However, as indicated in the discussion in this section, the opportunities appear to hold substantial potential for growth and, in some cases, for having an adverse impact upon Ontario producers of traditional industrial materials. It is not possible, given the state of our knowledge at this time, to describe these opportunities and potential dangers in great detail. This underscores the need to gather the requisite technical and economic information and to proceed without delay in assessing Ontario's strategic position.

a) Implications:

Some of the implications to be drawn by Ontario in the area of advanced materials are generic in terms of their applicability to other emerging technologies. These include:

- the necessity for analyzing one's position in the local and global community;
- the need for a commitment to long-term policies;
- the value of a commitment to quality and technological leadership;
- the importance of quality education and a skilled labour force;
- the critical need of industry, government and university collaborative efforts.

The first order of business for Ontario is to concisely analyze its strengths, weaknesses and current position in advanced materials within the global community and marketplace. While Ontario should not follow the Japanese model blindly, it should learn from it. Specifically, whereas Japan is devoid of natural resources, Ontario is well endowed with them. With these fundamental advantages, a different strategy is necessary.

Ontario has developed its energy and mineral resources well. Unfortunately, development has been limited mainly to mining and primary metals processing. It has not extended to secondary, high-value-added, product-oriented processes. Also, Ontario has lagged in the application of globally available state-of-the-art technologies. All too often, Canadian companies are content with the status quo of local markets and conditions.

It should be a matter of great concern that Ontario knows so little about the relationships between advanced materials opportunities and its existing materials base. This lack of awareness can easily lead to losing exciting industrial opportunities. It can also lead to a high vulnerability to disruptive changes that may adversely affect Ontario's traditional materials industries and the communities that depend on them.

b) Strategic Considerations:

Ontario, which represents 50 percent of the value of shipments in all manufacturing industries in Canada, needs a long-term strategy and policy for reindustrialization and revitalization based on the application of available high technology, including advanced materials. This process should have the following components: basic research, process and product development and commercialization.

With regard to basic research, Ontario cannot hope to compete with materials research facilities in the United States. However, this should not be viewed as a constraint, but as an asset. Much of the basic research in the United States is carried out in the universities and national laboratories, both of which are open to the public, which includes Canada. There is a need to take advantage of this situation. Ontario should learn how to tap this research base and utilize it as a resource. In fact, many of the top scientists and engineers in the United States are Canadians.

c) Action Plan:

To determine Ontario's strategic stake in various advanced materials, the province should assemble and continually update an inventory of materials opportunities during the next decade. The inventory would reveal current strengths and weaknesses, the time frames during which various opportunities are likely to be open, the status and importance of applicable research and development efforts in Ontario and elsewhere, the potential effects of opportunities on our secondary manufacturing base, and any "warning lights" of potential concern to our resource-dependent communities.

G. Technology Transfer: Brokerage and Gatekeeping

It is evident from Chapter 1 on selected technologies that developments and applications are increasing at a dramatic pace throughout the world. Many other countries have made concerted efforts in technology transfer by obtaining advanced intelligence on changes, licensing state-of-the-art technologies developed elsewhere and providing a brokerage function. Technology transfer is becoming of increasing strategic importance to a country's industrial base and trade prospects.

The National Research Council of Canada has stressed the urgency of increasing the level of technology transfer within Canada. "Canada's total output of technology amounts to less than one percent of the total world output ... It is a matter of considerable urgency that efforts be made to bring the ninety-nine percent of world technology forcefully and more conveniently to the attention of the possible exploiters, which are mainly to be found in industry."

It has been stated that "a technological solution must not only be a technical success, but also a market success. Unfortunately, not enough technologists perceive the importance of this statement. This is understandable since technologists are trained to reach a solution: the impact in the market place is someone else's problem. It follows, therefore, that someone must be able to combine an understanding of the user's problem, the technologist's approaches to the solution, and the effect on the marketplace."[1] The major difference between the public and private sectors, insofar as transferring technology is concerned, is the capability of their institutions to use the designated technologies. In the private sector, people are specifically designated to transfer technology to develop new products or processes, and management is conditioned to invest in these activities. In contrast, the public and academic sectors are rarely organized or funded to participate in the transfer process.

These organizational modes reflect the differences in the missions of the two sectors. Whereas in the private sector the mission is to provide a profit for investors, in the public sector the mission is to provide a service. The public sector possesses a limited ability to institutionalize the successful application of technology, thereby minimizing widespread use of the solution for the benefit of the taxpayers

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[1] Louis Mogavero, Technology Transfer and Innovation, 1982, Page 28

in other localities. Therefore, the technology transfer process in the public sector must direct itself to solution of problems.

Technology transfer means different things to different people. How it is interpreted for purposes of this paper will be discussed in the following section on implications. The major players in technology transfer in Ontario are university and research institutions, industry, government and international transfers.

The major technology transfer functions required in Ontario are:

- the dissemination of state-of-the-art information on technology developments and applications throughout the world as a basis for international transfers of technology to Ontario, and the identification of possible niche areas for export by Ontario producers;
- the interpretation of the impact and opportunities of technological advances for Ontario industry;
- the maximization of limited resources through collaborative research and development efforts across industry and universities;
- the availability of research undertaken in universities, research institutes and public agencies for broader exploitation throughout industry;
- the linking of research undertaken by an individual or a research organization to industry needs with the objective of achieving commercialization.

a) Implications:

For purposes of this discussion, two types of technology transfer are considered· brokerage and gatekeeping. Brokerage is defined as the transfer of technology from a research institution to an

organization that can commercialize a product or make use of it in its manufacturing processes. This, therefore, infers that a technology broker undertakes the traditional functions of all brokers. Two matching candidates are brought together and, if they decide to proceed, the broker takes a fee.

In IDEA Corporation this approach is carried out through the Research Investment Fund, where it takes an interest in research at an early stage of development and then assists in the commercialization of the product. Again, this is in return for some sort of quid pro quo, be it royalties, licensing or equity.

The form of brokerage engaged in by IDEA Corporation tends to be on a project-by-project basis. Areas that are not capable of obvious return or where some other country or organization is far more advanced are not, at this stage, pursued.

One of the major implications to be drawn from Chapter 1 is the critical need for Ontario industry to have access to state-of-the-art information on a broad range of technologies in order to remain competitive. Without a high level of intelligence as to what is happening technologically in the world, which will in one way or the other threaten the economic base of this province or demand new skills from management and labour, manufacturers will not be in a position to assess technological advances, nor will research necessarily be promoted in the appropriate directions. Given that Canada and Ontario cannot afford to compete with countries such as Japan and the United States in research investment, there is a critical need to be expert gatekeepers of what is being developed in other countries and what the opportunities are for licensing and joint venture. In addition, many small and medium-size companies do not have the resources to undertake either a research or a gatekeeping function internally. It is appreciated that it is impossible

to know all the developments on a worldwide basis. However, it is vital to know as much as possible about developments that will directly affect Ontario industry.

There are many individual gatekeepers in specific areas within Ontario. There are experts within firms with high degrees of specialization; there are professors or researchers at universities and government agencies who gatekeep, but also in areas of high specialization. There is a great reliance on informal networking where individuals in one organization or country make personal contact with individuals in another organization or country. Unfortunately, in some cases, the existing incentives are to retain information as opposed to diffusing it. This may be for reasons of competitive advantage by ensuring that no one else has an edge, for prestige, or because of the lack of a marketing incentive, particularly within universities, to actively promote their services and expertise to the private sector.

For the requirements to be met around planning, maximizing the use of limited resources, decision-making, skills development and general awareness, a more publicly available, better coordinated and more advanced gatekeeping function needs to be undertaken. It is in this context, therefore, that the following discussion on technology transfer takes place.

The Technology Centres and IDEA Corporation have been implemented with a view to undertaking specific functions in the technology transfer process. The Technology Centres are mandated to provide applications consulting assistance, information, outreach, training and demonstrations within their specific spheres of influence. It is expected that the level of knowledge developed by the Technology Centres will be sufficient to fulfill the gatekeeping function, but only in their designated areas.

On the other hand, IDEA Corporation has a mandate to act as a technology broker between research institutes and individual inventors and the private sector by finding commercial opportunities for new technologies. Given the financial imperative on IDEA Corporation to develop a return from its venture capital investments, the issue raised is whether this imperative will limit its potential as an effective broker for the province as a whole.

In brief, the issues are: who is responsible for fulfilling the gatekeeping function in those areas not already covered by the Technology Centres, and will IDEA Corporation be capable of fulfilling an overall brokerage function?

Under their current mandate, the Technology Centres are limited in terms of specific areas of expertise and will not be able to fulfill an overall gatekeeping function. It is also suggested that they should not be expected to fulfill such a function. Their strength lies in their expertise, and to dilute this in any way would reduce their usefulness in terms of being centres of excellence.

There are also constraints on IDEA Corporation in fulfilling an overall brokerage function. Because the credibility of IDEA Corporation will be based on the success of its investments, the priority concerns of senior management will have to lie on the venture capital side of the business. This raises the question of the priority IDEA Corporation, as a vital player in the venture capital arena, will be able to give to a technology brokerage function, particularly if this activity does not become a large revenue generator. The question is also raised as to whether a venture capital operation with obvious vested interests can be seen to be sufficiently objective to develop a reputation as a technology broker in a credible way.

IDEA Corporation as a venture capital operation will at all times have to adhere to confidentiality arrangements with clients and protect itself against possible allegations of plagiarism. In this environment, therefore, while IDEA Corporation may be able to develop an excellent reputation in given areas of technology and in the development of policies in support of technology, it is quite possible that it will not be able to fulfill practical aspects of technology brokerage. It should also be recognized that a technology brokerage function does not need to be accompanied by, or be part of, an investment function. The role of a neutral broker is seen as strictly that, linking research in one area to industry needs in another, which need not involve the broker in an investment capacity or in any other form of intervention.

The discussion above has been limited to the most recent provincial initiatives. This is because these initiatives were seen as a major contributor to technology transfer within the province. There is no doubt that they are a major contributor: the issue is whether this is on a broad enough scale.

It is apparent, furthermore, that gatekeeping can only be carried out effectively on a national basis. Therefore, any solution has to recognize the importance of federal/provincial linkages in a manner that satisfies both levels of interest.

b) Strategic Considerations:

The strategic considerations arising from the above discussion are threefold:

- Is an overall technology gatekeeping function required beyond that provided by the Technology Centres? If so, is this the responsibility of the private sector or is there a role for the government to disseminate early intelligence on a broad scale?

- If there is a gatekeeping role for government, how should the federal and provincial governments link together to provide an effective service?
- Can IDEA Corporation in its current and early form effectively undertake technology brokerage? If not, should IDEA Corporation be structured differently to allow it to undertake a broad brokerage function or should different mechanisms be developed?

c) Action Plan:

Given the urgency of establishing an effective, broadly based and accessible technology brokerage function in Ontario, there is a requirement to identify the needs to be served and the characteristics of any organization undertaking such a role to establish it as an automatic point of call for potential users. IDEA Corporation should be required to review candidly how it can effectively meet the requirements of a broad brokerage function while satisfying its investment and return imperatives.

The means by which an overall technology gatekeeping function could be undertaken should be defined. In view of the broad scope of technology gatekeeping, there is a critical need to review how existing players, including the National Research Council, provincial research organizations, universities and various technology centres, would fit within an overall structure. Any recommended structure should recognize the federal and provincial responsibilities for gatekeeping. For example, it may be that the federal government should be responsible for technology gatekeeping on a broad front that would be readily accessible to all the provinces, while the provinces should be responsible for an interpretative role in terms of the specific impact of technology on their economy. If possible, joint consultation should be undertaken to develop

a consensus and a national commitment to information gatekeeping,to determine the most appropriate roles for the various players, and to determine the priority assigned by each to joint efforts in this area.

3. ECONOMIC IMPLICATIONS OF TECHNOLOGY

A. The Producers of High Technology

One of the major implications to be drawn from this brief review is the need for a government, just like a business, to analyze where technologies are positioned prior to undertaking any major investments or programs of support. The issue is how to position our investments for maximum return in order to meet the competition. In this task, no one approach is necessarily appropriate across all technologies or industries.

There is little doubt that high-technology exports should form a cornerstone of Ontario's trade strategy. The present Ontario high-technology trade deficit must be urgently and directly addressed.

Rationalization by American based firms may well result in a reduced corporate manufacturing presence here, without market share erosion, as products would be shipped north across the border. Fears that American technology firms may reduce their presence in Canada may not be unfounded. Atari Inc. announced in spring, 1983, that it would be moving its entire video game manufacturing to plants in Hong Kong and Taiwan, and laying off 1,700 assembly workers at home base in Silicon Valley. As in the United States, Canadian manufacturing cannot compete with the Far East's ability to produce high volume goods while maintaining quality standards and paying workers an average of $1.20 U.S. an hour. Atari has joined Mattel Hong Kong (keyboard assembly), and Tandy will manufacture its home computers in Korea.

Glen St. John, president of Dynalogic Info-tech in Ottawa, stated: "in due course we'll move overseas." Gordon Gow, senior vice-president of Nabu, stated the same inevitability: "Canada is just not equipped to handle mass standardized production... It's quite an art."

"Production sharing," where the high labour skills and technology available in developed countries are combined with lower-cost

labour areas for processing and assembly, has seen U.S. imports grow under this arrangement by more than 20 percent a year since 1970. Yet a far more dramatic economic change is now about to be offered by new technology, this time in the service sector. Office sharing, the advent of the offshore office, is being examined for virtually the same cost reasons. American business consultants are looking to reduce office operating costs, which are expected to increase up to 45 percent of total business costs by 1990, by "office sharing" of clerical work in areas such as Jamaica. This has been made possible by the plummeting cost of satellite transmission to earth stations.

As pointed out in the current Trade Strategy of the Ministry of Industry and Trade, new international markets are being sought beyond Ontario's best customers, the United States and Great Britain. In this strategy, Ontario's high-technology producers may benefit through association and affiliation (sole sourcing arrangements) with its service exporters of health, education, engineering, architectural and environmental exports. A joint high-technology product/service approach may produce better results than the traditional exporter-supplier contracting arrangements.

Current federal and provincial government R&D incentives are sufficiently liberal to accommodate greater take-up. Since the Canadian industrial ethos is relatively unconcerned with prestige, defense or strategic materials requirements, and since Canadians can borrow readily from the unparalleled innovative strength in the United States and elsewhere, it would seem logical to transfer technically rather than re-invent, except in unique, independently developed niche areas such as communications. This is how Canada has created its present niches in the competitive export market.

The largest Canadian high-technology producers are R&D intensive. The issue is whether smaller companies can afford a sufficient commitment to remain competitive. Data does not appear to be available on this. Concern, however, has been expressed that a greater proportionate weight of total assistance should be directed to commercialization of innovations from prototype to production: in short, the "D" in R&D.

R&D functions are normally related to manufacturing activities. The Ontario economy is becoming more service-oriented, however, and its productivity performance has lagged seriously. Consequently, if Ontario industry is to be competitive, then the linkage between public and private R&D expenditures and public support for these should be fostered. The applied research and development of office automation and information systems networks in large service institutions, such as health and insurance, and these applications to small businesses may be one promising area of focus. Presumably, the same pay-back and quality results can be found here as on the plant floor - and with similar export potential.

The locational and size disadvantages of Ontario's embryonic high-technology industry, when viewed against the opportunities for its direct contribution to economic growth and ability to meet the competition, raise the issue of how to nurture the development of technological capabilities. Most suggestions are "hardware" oriented, that is, more R&D: greater targeting of support: better linkages to other investment areas: export assistance; and diffusion of technology.

Little is said about managing the effort aimed at such nurturing. Yet this has been one of Japan's great strengths and American corporate/labour/government weaknesses. For the Japanese, it has been a strategically designed plan requiring great teamwork.

For Ontario, the production and application of new technology across the industrial base of the province should be a strategic

priority. The design objectives, the required linkages and the expectations of governments and the business community are unclear at present. Greater resolve in this area is necessary to carve out a solid position beside our global competitors and trading partners.

B. Research and Development Consortia

a) Strategic Considerations:

One consequence of small size and working capital limitations is that research and development opportunities that would find an active take-up in other countries may not find a response in Ontario. A possible response to this problem may lie in greater research and development collaboration among groups of companies with similar interests and needs. Pooling of research resources around specific technology projects could, wherever appropriate, include university researchers and facilities as well.

The most prominent examples of larger-scale technology development collaboratives or joint ventures are provided by the Japanese experience. Eleven projects have been completed during the past decade, including ones on comprehensive automobile control technology, steelmaking processes using high temperature gas and pattern information processing systems. Nine other projects were ongoing at the end of 1982.

Each of the projects is coordinated by the Ministry of International Trade and Industry (MITI), while most of the actual R&D work is carried out by a consortium of industry participants. Each member company typically funds and performs defined sub-tasks and, in return, receives preferential access to any technological developments coming out of the project. Patents are held by MITI.

One example may serve to illustrate the scope and organization typical of these projects. The Flexible Manufacturing System Project embraces the following themes: total system, machinery technology, automatic diagnosis technology, design and management technology. The result is to be a test plant integrating the contributions of all the joint-venture partners. Twenty companies are participating, total expenditures during the period 1977-83 are $66.9 million Cdn., and the project is on schedule for completion in late 1983.

One rather striking feature of the Japanese cooperative R&D projects is the immense size of the participants. The modest size of many Canadian technology companies and their consequent need to spread research risks suggests that the idea of pooling resources may be even more appropriate here. As well, the impressive success rate of the Japanese projects strongly suggests that a sense of urgency is warranted.

It is interesting to note that, in the United States, there have been some recent cooperative developments in the R&D area, notably in microelectronics and computers. A number of organizations have formed limited partnerships to pool resources in undertaking research. One example is the Microelectronics and Computer Technology Corporation project called "Alpha Omega," which consists of 13 computer companies.

The combination of these strategic considerations, the need for risk-spreading and an urgent response, suggests a need to devise creative ways of extending any private cooperative research base to include university resources, whenever appropriate. As noted later in this chapter under Management Implications, Ontario is served by a broad university infrastructure whose diffusion of effort and resources frequently foregoes opportunities to help establish a world-class presence in key technologies. Integration of university and private collaborative R&D would, for well-defined projects, add an important "market test"

element for focusing research on key technology areas. The successful formation of a consortium implies a consensus among Ontario producers as to which technology niches require further support.

b) Action Plan:

The province should explore the needs of industry sectors for collaborative research and development efforts in key technologies and, if warranted, investigate ways in which such collaboration might be encouraged. Specifically, a review should be undertaken that examines what forms of private R&D consortia might be most appropriate, whether current anti-combines provisions would prohibit those forms and what types of government financial support would be most effective. Consideration should also be given as to how university R&D resources could be best incorporated into such consortia. Steps should be considered to ensure that all Ontario industry has a chance to benefit from a consortium's results. For example, the government may want to require as a condition for financial support that the members of an R&D consortium agree to license any resulting technology to other companies.

C. High Technology Application: Industrial Regeneration and Productivity

As noted in Chapters 1 to 3, introducing and effectively managing flexible automation equipment and systems can provide a powerful new set of competitive weapons for Ontario industries. Among them are higher productivity, lower cost, shorter product development times and more exacting quality control. It was also demonstrated that these competitive weapons are being applied in Ontario industries commonly thought to have reached a technological plateau of "maturity" and consequent competitive vulnerability.

While flexible automation is able to confer benefits on a variety of companies within a range of industries, it holds three key strategic implications for Ontario that deserve to be highlighted:

1. <u>It addresses some of Ontario's traditional competitive handicaps arising from small production runs</u>. The greatest benefits of flexible automation can be captured by mid-volume, mid-variety manufacturing operations. In any production system, unit cost and the flexibility to alter product mix quickly are intimately related to volume. In mass production, such as automotive assembly, the producer trades away flexibility for low unit costs. In batch production, such as customized items, the producer trades away low unit costs for the flexibility to produce a greater variety of goods more closely tailored to customer needs. The terms of this efficiency/flexibility trade-off are, for the most part, given by the existing production technology and relate to factors such as functional flexibility of the machinery, degree of equipment uptime and retooling costs.

Flexible automation shifts the terms of the trade-off in such a way as to benefit primarily low- to medium-volume operations. Flexible automation can be considered as a bridge that, to a significant degree, combines the low unit costs of mass production with the greater flexibility and variety of batch production. In short, it reduces the cost penalty faced by companies that are, for whatever reasons, now constrained to lower production runs. Consequently, many of our industries may be able to retain or attain competitive vigour by combining "economies of scale" with "economies of scope."

2. <u>It plays to one of Ontario's key strengths, a highly educated work force</u>. The discussion of new management and employee requirements in

Chapter 3 highlights the ways in which technology demands within the organization are altering job responsibilities and opportunities on the plant floor, in the office and in the executive suite.

In order to capture the full potential of flexible automation, companies must further develop their human resources as a point of competitive leverage. In doing so, a premium is placed on technical skills, team-work skills and adaptability. At the same time that these new requirements play to Ontario's strengths, they also pose challenges to parts of its education and retraining efforts that warrant urgent and serious attention. The management implications of these challenges are described in the following section.

3. Timing is essential. Most types of flexible automation technology have been available only during the past few years. It is expected that both further development and more extensive diffusion of this technology will accelerate before 1985. Our global competitors are adopting it now and, as indicated in Chapter 2, have staked out a lead over Canadian users. The competitive prowess of Japanese companies, especially in low-cost, high-quality manufacturing, could be strengthened considerably if this growing "diffusion gap" is allowed to expand further and as the extent of their managerial and employee experience with flexible automation grows along with it.

D. Working Capital and the Need for Recapitalization

The discussion on microelectronics and advanced manufacturing technologies indicates the competitive significance of adapting these technologies to products and processes. Many Ontario companies that do not rapidly adopt microelectronics, CAD/CAM and robotics will be at a

significant disadvantage in competing with companies that are able to produce higher quality, less expensive and more varied products. In addition, flexible automation is well suited for application to the shorter batch production runs of many manufacturers in Ontario.

a) Implications:

One of the most significant implications for Ontario is the need to recognize the importance of encouraging and assisting manufacturers in adopting these technologies. The Technology Centres are a major component of Ontario's response. As discussed earlier, the centres are raising the level of awareness of technology and assisting firms to apply and adapt to technology. While many firms are convinced of the opportunities offered by the technology, they do not have the working capital to make the investment, and appear to be having difficulty in securing loans from the traditional lending institutions.

b) Strategic Considerations:

The strategic consideration for Ontario is whether the current level of financial support to manufacturers is adequate to assist them to invest in technology to become more competitive and, if not, what are the most appropriate alternatives.

Some financial assistance for the acquisition of technological hardware and software may well be required in order to accelerate applications within small- to medium-size firms. However, any financial support must recognize the economic constraints currently facing the province.

There are a number of alternatives, ranging from tax incentives to increased government funding through existing bodies such as the Ontario Development Corporation, to joint government/financial institution

assistance program for recapitalization. The most appropriate alternatives will depend on a thorough analysis of the extent of the financing problem being faced by industry, the reasons for difficulties in securing traditional loans, and the type and scope of effort that is required to lever investment.

This analysis should also include a thorough review of all existing federal and provincial government funding programs, policies and tax incentives. It may well be that some of these need to be refocused, expanded or eliminated to more appropriately meet industry needs. For example, the training of supervisors and operators is an ongoing cost of CAD/CAM installation that typically costs one percent of the system cost a month. The continuing support of such training in the form of TIBI grants could be an important factor here.

Another strategic consideration is whether the current mix of tax incentives and direct grants is the most appropriate one to encourage the growth of high-technology companies and the use of advanced technology in conventional manufacturing industries. For example, new financial mechanisms may be required to help new companies that do not yet have enough revenue against which they can fully apply tax deductions.

The need for creative approaches to financing recapitalization is underscored by the heavy debt loads and consequent narrow room for financial maneuver of many companies emerging from recession. Timing for these companies can often be critical as they try to position themselves to match the technical and cost levels of their international competitors. Ironically, the inability of their balance sheets to accommodate the acquisition of advanced manufacturing technologies can mean that the rapid payback and substantial productivity gains characteristic of these technologies simply may not be realized. Consequently, their chances of recovery, and even survival, could be

impaired. This problem is accentuated when some of the companies most in need of capital restructuring are privately held.

There is also a need to consider means for drawing upon a broader base of investors, such as venture capital funds, as well as conservative investment vehicles like RRSPs or GICs. The current constraints on debt financing lend urgency to the lack of applying these non-traditional funding sources to capital restructuring in Ontario's manufacturing base.

Equipment leasing is another area worthy of attention. Private lenders frequently find leasing to be an attractive option for companies with high debt ratios. However, there appears to be no leasing market for advanced manufacturing equipment in Canada at the present time. In part, this reflects difficulties in assessing the risks associated with equipment resale, which are accentuated by the rapid pace of technical innovation and lack of experience with advanced manufacturing technologies. It is worthy of note that the Japanese government has successfully spurred robot leasing among small companies by subsidizing leasing rates through the Japan Robot Lease Company.

c) Action Plan:

The government should investigate the possibilities for focused incentives that surmount the obstacles many Ontario companies currently face in obtaining sufficient working capital and R&D support and allow the market place to designate winners and losers.

Consideration should be given to several financing options (separately or in combination) for assisting companies wishing to introduce advanced manufacturing technologies:

- Interest relief subsidies could be provided through traditional lending institutions. Government resources could be focused primarily on the initial-year debt hurdle facing many companies, while private lenders, alone, could determine the merit of eligible investment proposals.
- Arrangements could be made to encourage leasing of advanced manufacturing technologies. Private lenders frequently find the leasing option an attractive one for established manufacturing companies carrying heavy debt loads. Consideration should be given to ways in which the government might lever more leasing and, where appropriate, perform a brokerage function between equipment suppliers and manufacturers in need of retooling.
- Venture capital funds could be applied to eligible capital restructuring projects. Perhaps this could be done through an extension of the SBDC idea, whereby such capital restructuring projects would be considered as "new ventures."
- The government could foster the creation of private technology investment pools, with incentives for both investors and technology-based companies to draw upon them. Companies could use the equity funds either to develop a product in an eligible technology field or to introduce eligible manufacturing technology into their operations.

4. MANAGEMENT IMPLICATIONS OF TECHNOLOGY

Coping with the new technologies presents business management and government with some adjustment challenges of unprecedented scope. The major implications of these fall within three broad categories: training efforts both for those displaced by technological change and for those holding jobs that now require new skills: focusing some formal education resources into "centres of excellence" and coordinating their specializations with emerging strategic needs; and ensuring that public management responsibilities are focused, up-to-date, and provide the requisite catalytic direction and support to enhance private sector efforts.

A. Training

a) Implications:

i) The Job Displacement Problem:

During 1982, the combined effects of recession and structural decline in our industrial base placed an additional 100,000 Ontario manufacturing workers out of jobs compared to the previous year. The recovery is not expected to re-employ all of these workers, and most forecasts estimate a continuing unemployment rate of more than 10 percent in Ontario for the next several years at least.

In many cases, the resident skills of the unemployed have been rendered redundant by technological advance - machines are executing their tasks more efficiently. In numerous cases, former managers are dispossessed by a now "leaner and tougher" corporate world with decision, command and routine execution served by data and information processing and transmittal and guided by advanced management planning techniques. Chrysler's organizational restructuring, a requirement for government

support, is perhaps the most celebrated case. Twelve management levels were reduced to six, and management staff dropped from 40,000 to 27,000.

Ontario's unemployed, hundreds of thousands of youths, labourers and managers, represent a huge pool for any training/retraining agenda to raise Ontario's productivity. Without the skills for re-placement in office and industrial situations that are embracing the new techniques as discussed in Chapter 3, they represent a mammoth waste of resources and an awesome psychological detraction from efforts to becoming more internationally competitive.

Neither the future dimensions nor the sectoral or regional effects of technological unemployment are known with any degree of precision. Whatever the numbers, the potential for displacement is unsettling. The former minister of Employment and Immigration remarked that "we just don't know" the magnitude of technology-induced job losses or gains during the next few years. The expected loss of employment as a result of technology should not, however, lead to a decrease in technology investment, but rather to a concerted effort to reduce the negative effects at all levels. Many contend that, given long-term competitive realities, the failure to introduce flexible automation may have a greater effect on job loss.

ii). The Job Adaptation Problem:

Upgrading our capital resources through investment and retooling and our product offerings through R&D and quality control are, in themselves, insufficient responses to our productivity problem. A successful attack on the worst productivity record in the OECD also demands that Canada's corporate structures and the content of jobs be upgraded. This implies corporate reorganizing and retraining as preconditions.

The contrasts with most previous retraining efforts are centred in three areas:

. Broader target groups: The discussion in Chapter 3 stressed that job holders will face a continuing stream of prerequisite on-the-job skills acquisition. This is as true of the executive office as it is of the plant floor. What is more, all members of an organization must learn to work together more effectively in order to capture the opportunities that flexible automation and other technologies offer for boosting productivity.

. Broader training agendas: New technology and production management techniques require a new set of skills and attitudes. For managers, these include new capital budgeting methods, new ways of measuring the performance of technology and techniques for fostering more effective communication within companies. For first-line supervisors and floor workers, these include new operational skills, team problem-solving skills, and the ability to cope with additional responsibilities and pressures in directing their own job execution and quality performance.

. Closer consultation among government, industry and labour: Quite appropriately, most of the adaptation of job content and associated retraining will be undertaken within the corporate sector. Technologies are fluid and competitive pressures demand that industry incorporate them as swiftly and smoothly as possible.

Government, in its role as supplier of educational infrastructure and support catalyst of industrial adjustment, should monitor closely the progress and shortcomings of these corporate learning experiences.

b) Strategic Considerations:

It has become evident that decision makers within government and industry need better information about emerging technologies and

consequent human resources training needs. In Chapter 1, a number of technological effects are identified, including the widespread potential of advanced ceramics, the potential use of galvanized steel instead of lumber in housing construction and the substitution of fibre optics for copper in communications systems. Just as this information is not generally available to industry, nor is it likely to be available to human resource planners. The perception is apparently widespread in industry that the work force is too often inadequately trained. It follows that, unless human resource planners have available to them reasonably accurate projections of what the effects of technologies are going to be, the skills that are going to be required and the jobs that various technologies may displace, then the prospects for accurate human resources plans are greatly diminished.

It is widely accepted that relationships among our research laboratories, particularly between the universities and the manufacturing sector, do not foster the effective transfer of technology. One recurring theme is the difficulty that universities and industry have in communicating effectively with one another. Unfortunately, this problem extends into the training area as well, making it difficult for universities and industry to plan for future skill requirements.

It can be safely assumed that much more work has to be done in bringing industry and the universities together to deal with this issue. This will require that industry give priority to identifying and further defining its needs. It will also require that educational institutions move away from their somewhat isolated position to one in which they can better coordinate their training efforts with the needs of the private sector.

There are at present 17 universities and 22 community colleges in the province of Ontario. It is accepted that, particularly at the

university level, these institutions do not speak with one voice. They tend not to transfer information among themselves, particularly in the areas of research, but they do compete for money, for staff and to be the best in a number of duplicated areas. They produce a service that the entire community of Ontario identifies with, and it is a service that is seen as a singular provincial resource producing education and research. Yet in attempting to make contact with various institutions of learning, one is often faced with the fragmentation that exists. This fragmentation is yet another impediment in the way of dialogue between the educational institutions and the private sector that depends upon them.

In this context, it is possible to identify a further three areas that require consideration:

. Schools, universities and community colleges have to be an integral part of the technology transfer process, particularly in the "gatekeeping" function.

. Industry has to be more clear as to its training and educational requirements, while universities have to be prepared to learn from the lessons and needs of business for particular skills and expertise and to refocus their curriculum accordingly.

. A far greater degree of unity needs to be demonstrated by the universities in communicating with the public before effective discussions are likely to result.

The importance of training cannot be overstated. Along with natural resources, Ontario's remaining global competitive strength is a labour force that is attuned to technology, is highly skilled and can work in a sophisticated environment. It is only through this labour force that Ontario will be able to attract and implement the level of sophisticated manufacturing and services that will not be vulnerable to low cost labour offered by other countries.

c) Action Plan:

It is proposed that the Ministry of Colleges and Universities, the Ministry of Education and the Ontario Manpower Planning Commission be closely involved in all efforts regarding technology impact evaluations. Forecasts relating to technology effects should not only consider economic and geographic issues, but should also seek to identify skills, training and human resource needs.

The government should give high priority to ensuring that plans are produced within a defined period of time aimed at improving the level of coordination to overcome fragmentation within universities. Recognizing the problems inherent in such a suggestion, the areas of coordination should be focused and directed to current requirements of public needs. For example, the establishment of a central body with responsibility for liaison between the private sector and the universities might be considered.

B. Coordinated Specialization in Educational Investments

a) Implications:

Ontario is served by a large, broad educational and training infrastructure. While this system produces the well-educated work force that constitutes one of Ontario's competitive strengths, its diffusion of effort and resources forgoes opportunities to help establish a world-class presence in key technologies.

b) Action Plan:

Greater coordinated specialization of our educational investments could be profitably undertaken at the university and community college levels in both. For example, could Sir Sanford Fleming and Trent

University offer Ontario the technical training for robotics applications, or Algonquin College for microelectronics, or the University of Toronto/Canadore/ Lakehead for natural resources technology? Could Niagara and Mohawk, in concert with McMaster, provide the provincial technical training focus for metals technology and application, for example, to auto parts?

These examples are only meant to be suggestive. However, the kind of training-to-technology linkages they suggest promise built-in, planned leadership preparation through combining capabilities and investments already in the academic and business communities, in association with the Technology Centres. Further, given technological capabilities for information-sharing, joint efforts in some cases may simply mean program accommodation in several buildings on the same campus.

Finally, the visibility of such coordinated specialization of public training investments would attract and stimulate planning for greater business support and participation - a vital link in technology diffusion throughout the production system. A critical mass of research at many U.S. universities has fostered pockets of high-technology production nearby. Such focused educational and business training investment need not threaten liberal academic streams. Rather, the resulting efficiency from the concentration of expenditures may well serve both areas better.

C. Public Management Responsibilities

Although private sector managers are confronting most of the challenges presented by the new technologies, there are also public management responsibilities that must be assumed if the technological transition is to be successful. To maximize technology's contribution to productivity and to minimize its potentially disruptive impacts, the

Ontario government must share the lead in its application, rather than merely responding to its demands.

Technology and its immediate impact has caught government without an overall response. The heavy corporate and institutional requirements for capital renewal to incorporate new productive techniques, both in the manufacturing and service sectors, fail to find coordinated public policies, investments or technical programs. In education, a classroom computer is being developed. In health, automated diagnostic and laboratory services remain "point capabilities" without adequate connection to the treatment system. In industry, the Technology Centres are addressing industrial applications of existing technology but are not mandated to adequately undertake a sophisticated technology gatekeeping capability to provide "early warning" and dissemination of new developments across all technologies. Neither the Technology Centres nor IDEA Corporation is fully equipped to link university research and industry needs. In labour relations, efforts are stalled at considerations of quality of working life, while technology is providing it. In the universities, greater numbers of "paper entrepreneurs" are graduated from Ontario's MBA programs than in Japan.

In short, government policies bearing on technology are too often incomplete and fragmentary. This should not be too surprising considering the rapidity of technological change throughout the industrial world. However, given the serious implications that technological change holds for Ontario's industries. its work force and its position in the global marketplace, the government of Ontario should consider how it can

move beyond its current initiatives and coordinate its technology-related policies in a manner that maximizes the superb infrastructure that has been created within the province.

CHAPTER 7

TECHNOLOGY: THE ROLE OF THE ONTARIO GOVERNMENT

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CHAPTER 7

TECHNOLOGY: THE ROLE OF THE ONTARIO GOVERNMENT

1. INTRODUCTION

Earlier chapters of this paper have described the scope of technology trends and developments. It is evident that new directions and new initiatives are required if Ontario is to both meet the challenges and profit from the opportunities presented by new technology. Clear roles and responsibilities for the key players, including the government, are essential. In an international context, Ontario faces real constraints with a small domestic market and narrow technology base. Maximization of effort and resources, is therefore, absolutely essential.

Like the industrial revolution that has preceded it, this era of technological change promises to be as dramatic and sweeping in its economic and social consequences. It has the potential for radically restructuring existing patterns of world trade, production, consumption, investment and employment, and in fact is already doing so. It must be stressed that technology has no single dimension in terms of public policy, as it affects many ministry and agency mandates. Effective management of this phenomenon demands nothing less than the full commitment of Ontario's public and private sector resources and the development and management of an agreed-upon high-technology strategy. For this to occur, decisive and informed government leadership is required.

This chapter examines the role of the government of Ontario as it relates to technology. For purposes of this discussion, the role of the government is simplified into two parts: internal and external. In light of the proposed role of the government, it reviews the current structure of the government, the relationships among the major players within the government and the private sector, the alternatives for how the government can organize itself to focus on technology, and proposes a process and structure for involving the major players in jointly developing a technology strategy for Ontario.

2. THE COMPETITIVE CONTEXT

Chapter 4 has provided details of the many initiatives taken by the federal and provincial governments to stimulate technological growth. The following are some of the general trends: first, increased efforts to encourage the modernization of industry: second, a major focus on productivity improvement and product development: third, a strong emphasis on regional support and competition for technology industries: and fourth, limited federal-provincial cooperation and consensus in program development and execution.

Recent federal and provincial budgets confirm these trends. As well, the federal government's new technology strategy indicates a determination to push the priority in a regional context and in a manner that raises federal visibility. While the regional priorities of the federal government are responsive to the broad economic and political realities inherent in national policy formulation, its technology strategy does raise some fundamental questions. For instance, within the context of the strategy, the regional diffusion of technological support is aimed at fostering a technologically efficient national economy. Notwithstanding the desire of all Canadians to achieve this goal over the long term, the reality of past experience of nations that have achieved technological prominence shows a concentration of efforts within limited geographical areas over an extended period of time.

Factors such as the concentration of educational, research, extrepreneurial and financial resources played a major role in the development of California's Silicon Valley and Boston's Route 128. Government procurement and defence research were also significant. European nations and Southeast Asia have developed within the framework of a national technological strategy embodying a close working relationship between government and emerging industries. Japan is, of course, the classic example of a targeted national approach.

Equally important from Ontario's perspective is the need to ensure that both federal and provincial resources are utilized in a sustained and consistent manner to the benefit of Ontario industry. Duplication in the delivery of programs and conflicting policy approaches can be costly, confusing and ineffective. Ontario has a sustained record in developing its technological capabilities, largely due to the initiative and enterprise of its private sector. In order to build on and support the activities of the private sector, it is crucial that a harmonious working relationship exist in the support being provided by the federal and provincial governments.

In Canada, regional competition is layered on top of strong foreign competition, but there really is nothing new in this. Many observers trace U.S. high-technology problems to the lack of a federal strategy and leadership, to poor coordination of companies in the industry and to a preoccupation with short-run results - in contrast particularly with the situation in Japan. Compared with the United States, Canada faces even greater challenges with its small domestic market, relative capacity in business management, higher incidence of foreign ownership and lower rate of investment in modern manufacturing equipment.

The challenge in terms of federal-provincial relations is to harmonize the regional policies and optimally harness the resources employed across the country. This is a critical challenge if Canada is going to compete effectively in world trade. However, for the government of Ontario it is not the immediate priority. The first priority is to clearly define its optimum role in the context of the many technologically sensitive issues on the public agenda.

3. ONTARIO'S SUPPORT TO THE PRIVATE SECTOR

In Ontario, because of its industrial base, support for industry is a long public policy tradition. The government has consistently pursued a pro-business strategy. The major elements of this strategy are:

- structural economic policies to promote growth and expansion of the provincial economy:
- tax expenditure programs to stimulate business investment:
- contra-cyclical policies to minimize fluctuations in the business cycle and offset federal disincentives:
- fiscal policies designed to control public sector growth:
- direct technological innovation, product development and marketing through such corporations as Ontario Hydro, UTDC, and more recently through the Technology Centres and IDEA Corporation:
- consistent commitment to trade development, domestic import replacement and foreign market penetration:
- sectoral initiatives through BILD and other ministry programs, including labour retraining and education, aimed at increasing the supply of skilled labour and matching it more closely to market needs.

The ultimate goal of these policies and programs is sustained economic growth in a favorable business climate. In defining the role of the Ontario government, it is important to briefly review these major elements of Ontario's economic approach.

In terms of umbrella economic policies, the government has initiated major structural changes in the economy through various programs. Ontario provides generous tax incentives for R&D and other investments, and taxation policy continues to shift to encourage private and new enterprise, a thrust reinforced by the 1982 and 1983 Ontario

budgets. It is doubtful that more room exists for general tax relief, although there may be scope for further incentives to targeted sectors.

The government also pursues stabilization policies to help smooth the business cycle. A particular feature of this policy has been its sectoral approach, utilized yet again in the latest budget. For example, programs are implemented to assist specific sectors rather than to stimulate general demand. These programs, with a few notable exceptions, are supply-side oriented in that they are designed to increase investment and output in areas of potential high productivity and value added. The exceptions have largely been time limited items such as temporary tax cuts for automobile and household furniture sales and grants to first time home buyers.

The government of Ontario has been similarly innovative in its sectoral approach to technology by underwriting the Candu nuclear program of Ontario Hydro, developing light rapid transit systems and technology through UTDC, and funding research in universities, colleges and industries. However, with the structural problems of the 1970s came the realization of the need to establish a more formal framework for the future development of the provincial economy and for promotion of new technology. The major contribution of the BILD program is that it established a set of objectives for the future development of Ontario and mechanisms to help ensure that progress is made. The Technology Centres and IDEA Corporation are a major part of that strategy.

Individual ministries and agencies are also directly involved in many aspects of technology. As discussed in Chapter 5, these include the Office of the Future, remote sensing, communications, traffic management, medicine, energy, computers in education and agriculture. In many situations, these are joint ventures with external research organizations or institutions, or straight funding initiatives.

In reviewing the elements that help define the role for the government of Ontario in technology issues, what is being assessed is a difference of scope and emphasis. In the 1960s and 1970s, technology was sector specific. In the 1980s the scope is immensely wider, touching all aspects of economic life. The emphasis of government policy is still on competition for jobs and investment, but the changed economic climate makes that competition more complex. This change in scope and emphasis makes the coordination of policies more difficult, but even more necessary. While some of the elements of a technology strategy are already in place, the overall effort would benefit from a precise definition both within and outside government of the dynamics and dimensions of Ontario's leadership and priorities in this area.

4. ISSUES AND PROBLEMS

It is apparent that the government of Ontario pursues an active and supportive role in the economy. This should not change. However, it is time to redefine the task in terms of developing a coherent technology strategy and committing and organizing resources to accomplish that strategy. The task has two aspects, internal and external.

Internally, the government must ensure that all ministries, public agencies and institutions involved in or affecting technological or economic development maximize their contribution by operating in a coordinated fashion. There should be minimum duplication of functions and resources. The government should have specific goals and clear lines of communication. It can not be over-emphasized that the plethora of government strategies and programs in the Canadian context alone make it difficult for what are termed "footloose" technology industries to assess the merits of alternative geographic locations for research, development and investment in plant and equipment. A clear and consistent statement of Ontario's policies and programs, properly communicated to the domestic and international business community, is vital. The reality and commitment to a pro-technology framework in Ontario should be properly advanced and understood among key publics.

In terms of the internal structure of the government, the important roles to be considered include policy planning and development, program coordination, program monitoring and review, allocation of resources, and ministry, board and agency responsibilities.

All ministries apply some technology, and have an effect, to a greater or lesser degree, on technology policy planning and development. Existing internal coordination mechanisms include: Policies and Priorities Board, BILD, the Interministerial Committee on Microelectronics, the

Technology Directions Committee, the central agencies of Cabinet Office, Management Board of Cabinet and Treasury and Economics, and the Ministry of Industry and Trade as the key advocate ministry and coordinator of the Technology Centres and IDEA Corporation.

It is neither necessary nor wise to attempt to spell out a role for each individual ministry and agency in technology. Each has a statutory mandate and uses technology judiciously in pursuit of its mandate. However, given the importance of clarifying the relationships among the ministries, the following generic guidelines are offered to assist in the streamlining of internal functions:

- Line ministries should avoid in-house research and development activities, contracting out as much as possible to private industry and institutions and undertaking joint ventures, where appropriate.
- Line ministries should have input into the development of an overall government technology strategy and put forward proposals in the normal course of program development for technology and related research activities.
- A focal point should be established which would have overall responsibility for the coordination of government-wide technology activities.
- The central agencies should have input into the overall tactical and strategic decisions being addressed through the lead ministry, but should still advise the government independently on implications for the province via the normal central agency checkpoints.

External factors relate to the nature of the relationship between the government and its agencies and the private sector. A basic

requirement for the development of a comprehensive range of technology policies is that the government have its internal activities in order as described above. Requirements for establishing effective external relationships include:

- effective participatory mechanisms for setting priorities and goals, such as the Technology Centres, IDEA Corporation and the ORF;
- supportive programs such as tax expenditures, funding and marketing assistance:
- communications strategies to promote technology to the public and potential opportunities to business;
- information exchanges to encourage technology transfer among companies, industries, universities and government.

The environment within which Ontario makes decisions in the area of technology must be disabused of yesterday's prejudices or today's conventional wisdom. The harsh reality of competitive impact and development must frame the public policy process surrounding technology at all times. Cabinet will no longer be able to make decisions or to engage in long range planning without adequate early warning information on the implications of technology and input from the key players.

5. PRIORITIES

To provide a focal point for the government's role in technology policy, the following priorities must be addressed:

- Develop a technology strategy to support the private sector in closing perceived gaps and gaining leadership in selected emerging technologies.
- Secure a longer-term commitment from both the public and private sectors to technology development, application and management. The strengths of the Japanese approach are its focus on the long-term rather than a preoccupation with short-term gains and profits, and its consensus on national economic priorities and objectives. The large U.S. technology companies have formed high-technology combines for precisely this reason. European consortia are also taking the longer view to sustain market growth.
- Prepare an inclusive inventory of existing resources, strengths and weaknesses as a basis for industry planning and government program support. This basic step involves realistic comparisons with other jurisdictions in terms of industry and technology.
- Develop a more responsive educational and retraining infrastructure. The technological revolution is affecting all sectors of the economy: the factory, office, home, hospital and school. Planning is needed now to encourage acceptance and application of the new technology as well as to provide the required supply of skilled managers, technicians and other workers. Government has a role as a catalyst to refocus courses to provide appropriate skills and to disseminate information to industry on which retraining programs appear to

be most effective and what the trends are in needed skills.

- Develop international marketing support to ensure a broadened technology initiative to world markets in terms of Ontario's trade presence. This is particularly critical for Ontario's small and medium-size businesses.
- Continue to maintain a favorable climate that recognizes the peculiar "footloose" character of technology industries.
- Encourage maximization of federal-provincial resources, including perhaps some specialization and/or joint ventures in research activities, "centres of excellence." and targeted technology or industry sectors.
- Encourage more joint ventures between industry and universities in order to link research to industry needs.
- Encourage greater participation in overall goal setting and investment by the financial community.
- Develop communications strategies advancing technology and potential opportunities to key sectors.

6. KEY PLAYERS AND THEIR ROLES

The definition of a proper role for government also requires identification of the other key players and some definition of their roles. The major players are:

- governments;
- labour;
- public corporations, such as ORF, UTDC, Technology Centres, IDEA Corporation;
- private non-financial corporations;
- financial community;
- small business/inventors;
- private research groups and consultants;
- industry and trade associations.

If government is to show leadership, it must establish greater coordination with and among the major players. The primary roles and responsibilities of each of the major players are as follows:

- government - leadership, coordination, support, priorities, policies, programs, development of linkages, information base, ensuring the integrity of the framework for investment and expansion;
- labour - representation of its constituencies, identification of training and retraining needs, dealing with a changing environment;
- public corporations - catalysts in promising areas notbeing developed or serviced by the private sector, including R&D, production, marketing, information exchange, application;
- private non-financial corporations - primary creators of high-technology and related investment and jobs;

- financial community - financing, information, priorities:
- small business/inventors - innovation. development:
- private research groups and consultants - information, planning, priorities:
- industry and trade associations - leadership, coordination, support, information exchange, priorities.

7. ORGANIZATIONAL OPTIONS

In reviewing the alternative processes and structures through which government can best respond to the technological issues identified in this paper, several key considerations are integral to a meaningful and effective approach. Whatever process or structure emerges, it will not be successful without the active support, contribution and commitment of the major players. Nor will it have significant impact unless it is flexible enough in its approach to use the wealth of resources that already exists within the private sector and the Ontario government and has the capability to initiate policy direction through a well defined and managed approach.

Several options were reviewed against the following criteria: profile achieved, degree of joint participation, credibility, operational effectiveness, objectivity, acceptability to the major players, organizational flexibility and level of operating costs.

The options included an internal coordinating task force within the Ontario government. This approach was deemed to be both cumbersome and lacking in profile. As well, such an approach would exclude the private sector. A new committee of cabinet was also considered. However, given the pressures already placed on ministers, the logistics of supporting such a body, which in itself lacks the required technical expertise, and the existing role of BILD, this would not be a viable option.

Consideration was also given to the establishment of a new ministry of science and technology. While this option would provide profile and lead to a concentration of resources, it was not considered viable. The federal government's experience with the Ministry of State

for Science and Technology has not been entirely successful. The effect of reorganizing existing ministries and the time required to do so would significantly delay action. As well, the high operational costs and, to some extent, the lack of flexibility ingrained within a ministry structure do not, at least in the initial stage, lend themselves to recommending this option.

Even in the longer term. serious reservations have to be expressed as to whether a ministry with a mandate for science and technology could operate effectively. It is apparent throughout the paper that technology has an increasingly pervasive impact. It is, therefore, part of the mandate of many ministries and agencies. The perception of other ministries to a new ministry of science and technology would probably be negative, given the potential for adding another level of decision making and centralizing some of their functions. It would be a mistake were existing ministries to have any part of their specialist mandates removed from them. The contention of this paper is that all organizations, large and small, must maintain an awareness of technology. The creation of a separate ministry would threaten this within Ontario.

A separate innovation and technology division within the Ministry of Industry and Trade was also reviewed. While it is recognized that it would be impossible for any one division to provide a comprehensive response to the technological challenges that face this province, there is a need to co-ordinate and develop innovation and technology programs to assist in improving the productivity of Ontario's resources.

The major areas of activity to be focussed on by a new division could include new manufacturing processes. new product development and the introduction of new technology . In carrying out these activities, a division could act as a catalyst to gain consensus for co-operative strategies involving industry, labour, educational and financial institutions, and government. Further, it could act as a focal point within the Government of Ontario for support, liaison and co-ordination of information on technological issues and the identification of opportunities.

As well, the creation of a division would serve to demonstrate the government's awareness of, and commitment to, dealing with the challenges presented by technological change. It is recognized that a division in itself could not, and should not attempt to, provide all of the expertise and input required to respond to the technological issues facing Ontario. In view of the wide range of expertise and experience in the private, academic and public sectors, it is proposed that a division be based on a small core group which in turn would work with, and rely on, recognized expertise in various fields.

8. ACTION PLAN

The Government's capacity to adapt to changing technology and the implications for Ontario industry will be based on its ability to successfully refocus its own economic, fiscal, social, outreach, educational and leadership policies and instruments. The role of the government is first and foremost to establish a positive climate for assuring technological competitiveness of the private sector.

The following three actions are proposed to establish a process to enable a greater level of awareness to be developed and a coherent technology strategy for the province to be formulated based on input from all major players.

The strategic role of BILD, as a Committee of Cabinet, has been to consolidate and co-ordinate the Government's total economic development and focus on policy directions and investment initiatives in technology. This role should be taken to the next logical stage of building on its current investments and concentrating on identified priority areas. The government, as well, has to emphasize leadership, development and integration with the private sector.

A major contribution of BILD has been its establishment of a set of objectives for the future development of Ontario and mechanisms such as the Technology Centres and IDEA Corporation to help ensure that progress is made. The investment decisions and initiatives of BILD now need to focus on supporting long-term technological opportunities. This will underscore the province's commitment to a solid, productive industrial structure, as well as BILD's role in establishing a positive climate for industry competitiveness. Appropriate levels of resource allocation, new technology initiatives, leverage and industry support should be highlighted as key elements in a long-term technology strategy.

There should be recognition within the Ministry of Industry and Trade of both the need for senior private sector representations on technology issues to Cabinet and its Committees and for a focal point to address innovation and technology issues. Major groups that share a common interest in technology advancement in Ontario could be extremely valuable in providing ongoing advice to the government on priorities and strategies for technological application, development and new initiatives.

As the primary outreach, on behalf of the government, to the business community, it is proposed that an innovation and technology division be established within the Ministry of Industry and Trade to co-ordinate and focus on technology issues. This division should have responsibility for co-ordinating input from other ministries and developing technology-related programs and initiatives within the Ministry of Industry and Trade. The program delivery responsibilities of other ministries should be maintained. At the same time, the innovation and technology division should be provided with sufficient resources so that adequate priority can be given to effectively addressing the issues.

The government should, where possible, adopt the model of the Advisory Committee used in the development of the business plans for the Technology Centres when specific projects or initiatives are undertaken. This model has been very successful in ensuring the input of industry, academic and labour sectors from the conceptual through to the start-up and implementation phases of the Centres.

CHAPTER 8

TECHNOLOGY:

STRATEGIC OBJECTIVES AND PROPOSED ACTIONS

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CHAPTER 8

TECHNOLOGY: STRATEGIC OBJECTIVES AND PROPOSED ACTIONS

1. INTRODUCTION

This paper has addressed issues related to a variety of technologies, industry sectors, the economy and management/labour relationships. This is necessary in that technological change is central to an industrialized society and will be even more pervasive in an industrialized/informatics age.

It is apparent from the preceding chapters that, while enough is known to warrant concern, the province does not have sufficiently detailed information at this time to be confident of priorities or specific actions. This indicates that an appropriate level of resources needs to be applied to effectively research, develop and carry out technology strategy for the province. If such resources are to be used properly, an ordered list of priorities is necessary to provide overall direction.

There are clearly a number of technological, economic, management and government organizational implications raised in the paper that require further analysis before appropriate actions can be proposed. However, it is also apparent from the concerted action and concentrationof resources being focused on solving these problems by some other governments that these major implications should be addressed as early as possible by Ontario. The proliferation of technology initiatives at all levels of governments to assist the private sector and the lack of coordination in R&D initiatives raise major concerns. The level of resources to be brought to bear to meet the competition requires a common purpose among the major players in Ontario and a cooperative working relationship between the federal government and Ontario government to maximize resources.

A series of objectives that emerge logically from the paper have been developed for the province. These are accompanied by suggested priorities in both subject areas and process, which together provide preliminary action plans. These action plans are intended. at this stage, as a basis for developing firm, detailed recommendations designed to achieve the stated objectives. They cannot, and do not. pretend to spell out detailed actions. This function, along with the actual delivery, is the responsibility of specialist ministries. In classic planning terms, the proposed action plans represent the required step of identifying where we are now as a basis for developing a long-term strategic plan.

2. ACTION PLANS

The following action plans are meant to direct attention to areas where efforts are required either to further define Ontario's strategic position or to move toward capturing strategic opportunities. Each consists of an objective setting forth a suggested government priority along with the appropriate initiatives.

The first seven action plans are of two general types: those falling within the traditional mandate of the Ministry of Industry and Trade (A to E) and those of primary concern to other ministries (F and G). This section concludes with an action plan (H) for the establishment of a government process and structure to provide the necessary direction and support for furthering the suggested initiatives as well as other aspects of a technology strategy that may be required.

A. Recapitalization

a) Objective:

To encourage greater capital investment in Ontario's competitive renewal in ways that lever as much private sector response as possible, are cost-effective and recognize the financial constraints currently facing the government.

b) Action:

To investigate the possibilities for focused incentives that surmount the obstacles many Ontario companies currently face in obtaining sufficient working capital and R&D support and allow the marketplace to designate winners and losers.

Consideration should be given to several financing options (separately or in combination) for assisting companies wishing to introduce advanced manufacturing technologies:

- Interest relief subsidies could be provided through traditional lending institutions. Government resources could be focused primarily on the initial-year debt hurdle facing many companies, while private lenders, alone, could determine the merit of eligible investment proposals.
- Arrangements could be made to encourage leasing of advanced manufacturing technologies. Private lenders frequently find the leasing option an attractive one for established manufacturing companies carrying heavy debt loads. Consideration should be given to ways in which the government might lever more leasing and, where appropriate, perform a brokerage function between equipment suppliers and manufacturers in need of retooling.
- Venture capital funds could be applied to eligible capital restructuring projects. Perhaps this could be done through an extension of the SBDC concept whereby such capital restructuring projects would be considered as "new ventures."
- The government could foster the creation of private technology investment pools with incentives for both investors and technology-based companies to draw upon them. Companies could use the equity funds either to develop a product in an eligible technology field or to introduce eligible manufacturing technology into their operations.

B. **Collaborative R&D**

a) Objective:

To ensure that our limited research resources are effectively harnessed to create and support world-class positions in key technology areas.

b) Action:

To explore the need for collaborative research and development efforts in key technology sectors and, if warranted, to explore ways in which such collaboration might be encouraged. Specifically, a review should be undertaken to examine:

- what forms of private R&D consortia might be most appropriate;
- whether or not such arrangements are consistent with current anti-combines provisions;
- what types of government financial support would be most effective.

Consideration should also be given as to how university R&D resources could be best incorporated into such consortia. Steps should be considered to ensure that all Ontario industry has a chance to benefit from a consortium's results. For example, the government may want to require as a condition for financial support that the members of an R&D consortium agree to license any resulting technology to other companies.

C. Technology Transfer: Brokerage and Gatekeeping

a) Objective:

To emphasize the function of technology transfer, encompassing both brokerage and gatekeeping, in Ontario in order to ensure:

- the dissemination of state-of-the-art information on technology developments and applications throughout the world, as a basis for international transfers of technology to Ontario, and the identification of possible niche areas for export by Ontario producers:
- the interpretation of the impact and opportunities of technological advances as a basis for identifying what steps need to be taken to nurture our competitive position:

- the maximization of limited resources through collaborative research and development efforts across industry and universities;
- the availability of research undertaken in universities, research institutes and public agencies for broader exploitation throughout industry;
- the linking of research undertaken by an individual or a research organization to industry needs with the objective of reaching commercialization.

b) Action:

Given the urgency of establishing an effective, broadly based and accessible technology brokerage function in Ontario, there is a requirement to identify the needs to be served and the characteristics any organization undertaking such a role must possess to establish itself as an automatic point of first call for potential users. IDEA Corporation should be required to review how it can effectively meet the requirements of a broad brokerage function while satisfying its investment and return imperatives.

The means by which an overall technology gatekeeping function could be undertaken should be defined. In view of the broad scope of technology gatekeeping, there is a critical need to review how existing players, including the National Research Council, provincial research organizations, universities and various technology centres, would fit within an overall structure. Any recommended structure should recognize the federal and provincial responsibilities for gatekeeping. If possible, joint consultation at the federal and provincial levels should be undertaken to develop a consensus and a national commitment to information

gatekeeping, to determine the most appropriate roles for the various players, and the priority assigned by each to joint efforts in this area.

Based on the initial analysis undertaken in this paper, it is apparent that there are a number of technologies where Ontario needs an increased level of intelligence as a basis for identifying strengthens priorities and opportunities. The leading examples where increased technology gatekeeping is required include optoelectronics, biotechnology, advanced materials and the information industry. The following review objectives and actions in each of these areas.

i) Optoelectronics

To identify what supportive actions may be needed to maintain and expand on our competitive position in optoelectronics and to foster future niches.

This requires, first of all, acquisition of the requisite technological/industrial intelligence base within government. This will allow for the development of a coherent understanding of the components of the optoelectronics industry and the nature of Ontario's strengths and weaknesses. Attention should also be devoted to assessing any potentially adverse effects of rapid optoelectronics applications on Ontario suppliers of some older technologies, principally copper wire.

ii) Biotechnology

To review the leading areas of biotechnology research and Ontario's opportunities.

If conditions warrant, there is a need to immediately seek to further our position by anchoring an Ontario presence in two ways:

- by focusing our current efforts more effectively in order to create a critical mass of biotechnology R&D;

- by attracting more researchers to Ontario through such means as increased research funding and the establishment of university chairs in biotechnology.

iii) Advanced Materials

To determine Ontario's strategic stake in various advanced materials.

The government should construct and continually update an inventory of materials opportunities for Ontario during the next decade. The inventory should include: current strengths and weaknesses, niches of opportunity, the time frames during which the various opportunities are likely to be open, the status and importance of applicable research and development efforts in Ontario and elsewhere, the potential impact of opportunities on our secondary manufacturing base, and any "warning lights" of potential concern to our resource dependent communities. Such action is critical if Ontario is to effectively capitalize on its advanced materials opportunities and contribute to the development of industry.

iv) Information Industry

To obtain intelligence on the components of the information industry and where Ontario's strengths and weaknesses lie.

There is a need to develop recommendations on the most appropriate role for the government in supporting this industry and determining priorities for resource allocation.

D. <u>Software Industry</u>

a) Objective:

To develop a competitive software industry in Ontario that assists in establishing Ontario's position in the information industry,

supports the specific requirements of manufacturing and service industries by developing customized software to meet their specific needs, attracts software specialists and ensures our existing expertise does not emigrate, and capitalizes on the investment and expertise of our universities, such as Waterloo.

b) Action:

There is a need to immediately review alternative strategies for developing computer software industry in Ontario with recommendations for a government policy. The review should include an assessment of the software industry in Ontario and its competitive position, present constraints and opportunities, specific needs of the manufacturing and service sectors, potential market niches both domestically and for export, current disincentives in funding programs and tax incentives, and how R&D marketing and distribution needs can be most appropriately supported. The immediacy of developing a coherent software policy in Ontario is critical, given the increasing dependence of secondary manufacturers and service industries on specialized software, if they are to remain competitive. This is an obvious area for close consultation with the private sector and colleges and universities.

E. Supply of Custom Chips

a) Objective:

To ensure that the electronics industry and existing and potential users of microelectronics have access to state-of-the-art semiconductor developments and a reliable supply of custom chips to allow them to foster niche areas of expertise and protect their competitiveness.

b) Action:

To develop a well-defined, cooperative strategy among industry, government and university sectors to support a competitive silicon-based electronics industry and secondary manufacturers in Ontario. This strategy should include the following components:

- start-up assistance to new companies:
- continued support to educational institutions and encouragement of cooperative undertakings between and among universities and industry;
- investigation of the potential demand for custom chips by Ontario manufacturers and their arrangements for securing long-term supplies of chips. If arrangements are inadequate, a report should be immediately prepared recommending alternative strategies for guaranteeing supplies to manufacturers and for supporting a more competitive electronics industry in Ontario.

F. College and University Coordination

a) Objective:

To ensure that our educational resources for technology development and training are focused as effectively as possible and are kept abreast of new technology opportunities.

b) Action:

There is a need to foster greater coordinated specialization of our educational investments both at the leading edges of research and development and for application of technology and training. There is also a need for a gatekeeper function to identify opportunities as well as

vulnerabilities and to recommend to the government appropriate areas to support.

G. Training

a) Objective:

To ensure that Ontario has a labour force that is fully qualified to adapt to new technologies and is able to harness its competitive potential as swiftly and smoothly as possible.

b) Action:

It is proposed that the Ministry of Colleges and Universities, the Ministry of Education and the Ontario Manpower Planning Commission be closely involved in all efforts regarding technology impact evaluations. Forecasts relating to technology effects should not only consider economic and geographic issues, but should also seek to identify skills, training and human resources needs.

The government should support plans within a defined period of time aimed at improving the level of coordination to overcome fragmentation within universities. Recognizing the problems inherent in such a suggestion, the areas of coordination should be focused and directed to current requirements and public needs. For example, the establishment of a central body with responsibility for liaison between the private sector and the universities might be considered.

H. Government Process and Structure

a) Objective:

To ensure that a process and a structure are established to enable a greater level of awareness to be developed, adequate resources

to be focussed on priority areas, and a coherent technology strategy for the province to be formulated based on input from all the major players.

b) Action:

The strategic role of BILD, as a Committee of Cabinet, has been to consolidate and co-ordinate the Government's total economic development and focus on policy directions and investment iniatives in technology. This role should be taken to the next logical stage of building on its current investments and concentrating on identified priority areas. The government, as well, has to emphasize leadership, development and integration with the private sector.

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There should be recognition within the Ministry of Industry and Trade of both the need for senior private sector representations on technology issues to Cabinet and its Committees and for a focal point to address innovation and technology issues. Major groups that share a common interest in technology advancement in Ontario could be extremely valuable in providing ongoing advice to the government on priorities and strategies for technological application, development and new initiatives.

As the primary outreach, on behalf of the government, to the business community, it is proposed that an innovation and technology division be established within the Ministry of Industry and Trade to co-ordinate and focus on technology issues. The division should have responsibility for co-ordinating input from other ministries and developing technology related programs and initiatives within the Ministry of Industry and Trade. The program delivery responsibilities of other ministries should be maintained. At the same time, the innovation and technology division should be provided with sufficient resources so that adequate priority can be given to effectively addressing the issues.

The government should, where possible, adopt the model of the Advisory Committee used in the development of the business plans for the Technology Centres when specific projects or initiatives are undertaken. This model has been very successful in ensuring the input of industry, academic and labour sectors from the conceptual through to the start-up and implementation phases of the Centres.

APPENDIX A

FEDERAL GOVERNMENT SUPPORT FOR TECHNOLOGY DEVELOPMENT

The federal government provides support for technology development through a variety of mechanisms, ranging from tax incentives to grants, loans and contracts for goods and services.

1. TAX INCENTIVES

Section 37 of the Income Tax Act allows taxpayers to deduct all current and capital expenditures for R&D in the year in which they were incurred. The government has also introduced in recent budgets two major tax incentives for R&D in Canadian industry.

A. Special Allowance

Since 1978, corporations carrying on business in Canada have been allowed to deduct a further 50 percent of current and capital R&D expenditures over and above the average of R&D expenditures incurred in the previous three years.

B. Investment Tax Credit

Scientific research expenditures made after November 16, 1978, are also eligible for an investment tax credit.

Individuals and corporations can invest in R&D ventures through a limited partnership to use the 100 percent deduction and the investment tax credit against their other income. This will lower the risk/reward ratio of such an investment.

The value of the special allowance and investment tax credit for R&D is estimated to be worth about $120 million.

2. FINANCIAL ASSISTANCE FOR RESEARCH AND DEVELOPMENT

A. Industrial and Regional Development Program (IRDP)

The new IRDP is a consolidation of a number of existing federal programs, including EDP, STEP, RDIA and other ITC/DREE industrial-assistance programs, as of July, 1983, under the Department of Regional Industrial Expansion (DRIE).

IRDP is an umbrella program consisting of six elements - innovation, modernization/expansion, development climate, establishment, marketing and restructuring. The first three are most relevant to scienc[e] and technology activities and are discussed here. Innovation projects ca[n] be combined with projects under other IRDP elements. Projects eligible for ILAP or CIRB assistance cannot be considered under IRDP. The level o[f]

IRDP assistance for new projects will be based on a development index composed of the following factors:

- rate of employment in census area;
- per capita income in census area;
- fiscal capacity of province in which the census area is located.

Based on the development indices, four "tiers" of available financial assistance have been established. Funding varies depending on the location of the project.

a) IRDP Innovation:

IRDP Innovation is for research design development and demonstration projects of technologically innovative products and production processes and for consulting studies on related feasibility, market research, technology transfer and venture capital matters.

Science and Technology Objectives:

- to encourage and support the creation, application or adaptation of technological advances entailing significant technical risks to commercially exploitable prospects for industrial development;
- to enhance the technological capability of an applicant for strategic reasons that may not lead directly to identifiable sales but are important to regional development priorities;
- to foster the R&D, demonstration or adaptation of pollution abatement technology to reduce or eliminate pollution caused by commercial operations.

Target Clientele:

- commercial operations, notably incorporated firms engaged or to be engaged in manufacturing and processing activities (operations within the service industry can be designated as commercial operations for IRDP purposes).

Nature and Level of Assistance:

- negotiable contributions up to 50 percent in tier 1, 60 percent in tier 2 and 75 percent in tiers 3 and 4 of eligible operating and capital costs for product and process development projects and related studies;
- repayable contributions, as above, for new or improved and technologically advanced product or production process projects not entailing significant technical risks.

b) IRDP Modernization and Expansion:

i) IRDP Modernization and Expansion is for projects incorporating microelectronic devices in products, processes, production methods or facilities and for consulting studies on project feasibility.

Science and Technology Objectives:

- to enhance the productivity of applicants' operations by the custom design or first-time use of microelectronics technology.

Target Clientele:

- commercial operations.

Nature and Level of Assistance:

- negotiable contributions up to 50 percent of eligible costs in tier 1, 60 percent in tier 2 and 75 percent in tiers 3 and 4.

ii) IRDP Modernization and Expansion is also for projects involving the acquisition of new, advanced machinery and equipment and for consulting studies on project feasibility and productivity improvement techniques.

Science and Technology Objectives:

- to improve sionificantly the productivity of a commercial operation by supporting the acquisition of advanced machinery and equipment and/or by facilitating studies on the adoption of modern productivity improvement methods.

Target Clientele:

- commercial operations, especially in the manufacturing and processing sector, and selected services sector firms related to these and tourism operations.

Nature and Level of Assistance:

- negotiable contributions up to 25 percent of eligible capital costs in tier 1 for machinery and equipment projects whose approved capital costs exceed \$250,000; up to 35 percent in tier 2 for projects exceeding \$100,000; up to 50 percent in tier 3 for projects exceeding \$50,000; and up to 50 percent in tier 4 for projects over \$25,000;

- negotiable contributions for related consulting studies up to 50 percent of study costs in tier 1, 60 percent in tier 2 and 75 percent in tiers 3 and 4.

Note that IRDP financial assistance for any project in combination with assistance from other federal, provincial and municipal government programs and tax credits such a project is likely to receive is not to exceed 90 percent of the eligible costs.

c) IRDP Development Climate:

IRDP Development Climate is for studies, courses, special common services and facilities for, in part, scientific and technical activities and capabilities related to and benefiting industrial development.

Science and Technology Objectives:

- to provide information and advice to and to carry out research, design, development, testing for commercial operations of products and processes involving the application of specialized scientific and technological capabilities.

Target Clientele:

- non-profit technological institutes, business associations, universities, cooperatives and municipal corporations.

Nature and Level of Assistance:

- negotiable grants and contributions for eligible operating costs in the expectation of the applicant becoming financially self-supporting;

- negotiable contributions toward eligible capital assets on a cost-shared basis with provincial or municipal governments for such projects in tiers 2, 3 and 4.

B. Industrial Research Assistance Program (IRAP)

This program was established in 1962, and is administered by the National Research Council (NRC). It constitutes the main thrust of NRC's support to Canadian companies in their efforts to expand through new product development. It encourages applied research in Canadian industry, with the objective of increasing the calibre and scope of industrial R&D in Canada in a business environment.

- IRAP-C: field advisory service;
- IRAP-F: technical information service;
- IRAP-H: contributions to firms employing undergraduates;
- IRAP-L: contributions to laboratory investigation;
- IRAP-M: contributions to small projects;
- IRAP-P: contributions to large projects.

It pays the salaries of university and technological college students who help small firms with problems related to production, manufacturing and preparation of product designs, quality control and plant layout.

C. Defence Industry Productivity Program (DIPP)

This program was established in 1968 and is administered by the Department of Industry, Trade and Commerce.

DIPP is designed to enhance the technological competence of the Canadian defence industry in its export activities by providing financial assistance to industrial firms for selected projects. Emphasis is placed on those areas of defence technology having potential for defence or associated civil export sales. Assistance may cover: the development of products for export purposes; the acquisition of modern machine tools and other advanced manufacturing, test and quality control equipment to meet exacting military standards; pre-production expenses to establish manufacturing sources in Canada for export markets, and defence market feasibility studies.

Only companies in the defence industry, or subcontractors to the defence industry, are eligible. Assistance is given in the form of contributions and repayable loans on a negotiated shared-cost basis. Allied governments and other companies may be involved.

1982/83 - $151.9 million ($148.4 million contributions, $3.5 million loans)
1983/84 - (est.) - $170 million

D. Program for Industry/Laboratory Projects (PILP)

This program was initiated in 1975 and is administered by the National Research Council (NRC). It is designed to promote a more rapid transfer of results from NRC laboratories and other federal laboratories to industry in situations where there are important opportunities for Canadian industrial exploitation. The program is designed to help overcome barriers to industrial use of the research results of government laboratories. This is done by funding work that will advance development, allow better identification of the eventual product, expose the economic factors affecting the product or process and identify its place and position in the marketplace.

Projects for funding under PILP are selected from proposals that:

- are aimed at an important Canadian need or opportunity;
- derive from federal research or are in an area of interest to federal agencies where their staff and facilities can make significant contributions;
- involve as prime performers Canadian companies with technical capability and an adequate business base;
- give evidence of intent of the performer to commercialize the results either by himself or along with other identified parties in Canada;
- identify the major barriers to commercialization and the probability of high economic return and describe a procedure to overcome the barriers identified.

Funds are provided through the negotiation of a contribution arrangement and occasionally via research contracts with Canadian companies.

1982/83 - $17.4 million
1983/84 - (est.) - $20.6 million

3. SCIENTIFIC AND TECHNICAL INFORMATION

The Canada Institute for Scientific and Technical Information (CISTI), which is part of NRC, provides a general library service, acquiring and storing material on a wide range of scientific and technical information that is made available to all businesses.

4. TRAINING ASSISTANCE

A. New Technology Employment Program (NTEP)

This program, established in 1980, is administered by the Canada Employment and Immigration Commission (CEIC). It provides salary assistance to small firms, individuals, associations, research institutes and crown corporations to hire technically qualified recent post-secondary graduates who cannot find employment in their discipline in the development of innovations in manufacturing products or processes, and in the development and application of conservation and alternative energy techniques and programs. Priority attention is given to the following areas in conjunction with employment priorities:

- microelectronics;
- biotechnologies;
- materials technology;
- manufacturing science - including robotics and CAD/CAM;
- communications technology;
- energy-related R&D;
- geophysical exploration;
- instrumentation technologies;
- transportation technologies;
- ocean technology;
- toxicology.

The federal government contributes up to 75 percent of the wages paid to an eligible individual to a maximum of $290 per week per job. Contributions are provided for a maximum of 12 continuous months, and are limited to a maximum of $150,000 for each employer.

1982/83 - $3.6 million

B. National Industrial Training Program (NITP)

This Canada Employment and Immigration Commission (CEIC) program is composed of two elements: General Industrial Training (GIT) and Critical Trade Skills Training (CTST).

The objective of GIT is to assist employers to meet their skill needs for workers in middle and higher level skills, to assist in adaptation to industrial and technological change and to train adult workers facing serious barriers to employment. Training assistance will be provided for a period of up to one year in areas such as equipment operation and maintenance and word processing.

1982/83 - $77 million
1983/84 - (est.) - $86.9 million

CTST is directed toward training workers for high-skill occupations in which there will be a national or regional shortage unless training efforts are increased. Training assistance will be provided for up to two years for systems analysts, robotics programmers, electronics technicians, etc.

1982/83 - $54 million
1983/84 - (est.) - $99.2 million

5. TECHNOLOGY SUPPORT THROUGH PROCUREMENT

A. Contracting-out Policy

In 1972, the government established a contracting-out policy that directs that government requirements for mission-oriented science and technology are to be contracted out to the private sector, preferably to Canadian industry, unless a department can justify intramural or foreign performance.

Although the contracting-out policy is primarily a procurement policy, it is intended to promote the development of a Canadian industrial R&D capability. It is anticipated that $275 million worth of government science requirements will be contracted out in 1983/84.

B. Unsolicited Proposals (UP)

In 1974, the government expanded the contracting-out policy to cover unsolicited science and technology proposals submitted by industry within the mission of a government department. The UP program is intended to permit the government to respond quickly to sound, unique proposals from the private sector in support of government science missions.

1982/83 - $15 million
1983/84 - (est.) - $15 million

C. Source Development Fund (SDF)

The Source Development Fund was established in 1981 to allow the government to make better use of procurement as an industrial development tool. The SDF pays for the incremental costs of high-technology

procurement-related developments that need up-front funding. The fund also supports product innovation and maximization of Canadian content.

$10 million a year (1981/82; 1982/83; 1983/84)

D. Profit Policy

Administered by the Department of Supply and Services, this directive sets out the policy and guidelines for the calculation of the profit applicable to negotiated contracts with the Canadian suppliers for both products and services to special specifications with total costs of $1 million or more.

The amount of profit to be applied will be calculated on the basis of four factors: capital employed, general business risk, contractual risk and contractor's contribution to a Canadian value added strategy.

6. TECHNOLOGY SUPPORT THROUGH INSTITUTES

The Department of Industry, Trade and Commerce administers three types of programs to encourage the diffusion of technology in the private sector.

1982/83 - $1.45 million

A. The Industrial Research Association (IRA)

In cooperation with industrial groups, four industrial research associations have been created to organize research and development activities important to these groups. In their early years, the associations are supported by grants ($200,000 a year for five to seven years) and by membership subscriptions obtained from participating companies. As the associations develop, membership subscriptions and contracts with individual firms for specific, proprietary R&D work are expected to defray the total operating costs of the associations.

Three of the four industrial research associations are now financially self-sufficient.

B. Industrial Research Institutes (IRI)

The Department of Industry, Trade and Commerce introduced this program in 1967 to assist Canadian universities to establish and administer industrial research institutes to provide scientific services for industrial firms unable to maintain research facilities and personnel of their own.

Assistance is provided by grants to help cover salaries and small administrative costs for a maximum of eight years.

Industrial research institutes have been established at nine educational institutions.

C. Centres for Advanced Technology

This program was instituted by the Department of Industry, Trade and Commerce in 1968 to provide funds to permit universities and other institutions to establish and operate units with specialized capabilities for the benefit of industry. Support is limited to a maximum of seven years.

Under contract, these centres provide assistance to individual firms with development projects in specific technological areas. A similar program in the field of microelectronics has also been established.

CENTRES FOR ADVANCED TECHNOLOGY

INSTITUTION	CENTRE
College of Cape Breton	- Atlantic Coal Institute
Saskatchewan Research Council	- Centre for Advanced Instrumentation
Technical University of Nova Scotia	- Institute of Fisheries
McMaster University	- Canadian Institute of Metal Working
Ontario Research Foundation	- Centre for Powder Metallurgy
University of Toronto	- Biomedical Instrumentation Development Unit
	- Microelectronics
British Columbia Research Council	- Centre for Ocean Engineering
University of Western Ontario	- Systems Analysis, Control and Design Activity
Nova Scotia Research Foundation	- Centre for Ocean Technology
Manitoba Research Council	- Canadian Food Products Development Centre
	- Health Industry Development Centre
McGill University	- Program for the Measurement and Control of Particles and Vapours
University of Waterloo	- Waterloo Process Development Centre

MICROELECTRONICS CENTRES

Dalhousie University
Universite de Moncton
University of British Columbia
University of Alberta
University of Manitoba
Universite de Sherbrooke
University of Toronto

D. Canadian Industrial Innovation Centres (CIIC)

There are two CIIC centres to date, at the University of Waterloo and at the Ecole Polytechnique de Montreal.

Their purpose is to assist entrepreneurs and inventors to commercialize their inventions and to teach entrepreneurship by involving students in the commercialization of innovations. The innovations themselves can originate in any sector of the economy and can include the commercialization of an innovation. Fees are charged for services provided.

Federal funding for these centres is up to $1 million a year for each centre for five years, after which time the centres are expected to be self-sufficient.

7. DEPARTMENTAL PROGRAMS

Several federal departments have programs designed to assist technology development in specific industries or areas. These include:

A. Industrial Energy Research and Development Program (IERD)

This Department of Industry, Trade and Commerce program, introduced in 1977, encourages and assists Canadian industry in undertaking research and development leading to new and improved processes, equipment, products and systems of an energy-conserving nature. It also encourages the widest possible use of the technology developed under the program by commercial exploitation in industrial or consumer markets or by licensing.

The sharing ratio depends on the technical risk and/or the degree to which the developed technology can be used by other corporations.

1982/83 - $8 million
1983/84 - (est.) - $8 million

B. New Crop Development Fund (NCDF)

This Agriculture Canada program is designed to bridge the gap between basic research and commercial production through development research and to share the financial risk and burden of larger scale field and equipment testing.

1982/83 - $750,000

C. Purchase and Use of Solar Heating (PUSH)

This Department of Public Works program supports the preferential purchase of Canadian-made solar space and water heating equipment for Government of Canada buildings.

1982/83 - $17.2 million

D. Energy From the Forest (ENFOR)

This program finances R&D related to the production, harvesting and utilization of forest biomass for energy.

a) **ENFOR: Biomass Production:**
This program deals with the forest-oriented aspects of biomass energy under contract by private sector researchers and consultants.

1982/83 - $3.7 million
1983/84 - (est.) - $3.7 million

b) **ENFOR: Biomass Conversion:**
This program is concerned with the transformation of biomass raw materials into prepared fuels or energy intensive chemicals.

1982/83 - $4.1 million
1983/84 - (est.) - $4 million

E. Development and Demonstration of Resource and Energy Conservation Technology (DRECT)

The DRECT program funds the development of new technologies to produce energy from industrial and municipal wastes and is administered by Environment Canada. It supports feasibility studies and development and analysis of energy recovery proposals.

1982/83 - $1 million
1983/84 - (est.) - $1 million

8. INTELLECTUAL PROPERTY

Canadian Patents and Development Limited (CPDL)

CPDL is the Crown corporation responsible for arranging the commercial exploitation of inventions arising from research carried out by government departments, universities and public research institutions. Businesses and individual entrepreneurs may obtain rights to develop and produce inventions that have been assessed for patentability and commercial use.

CPDL maintains an inventory of inventions that are available for licence. These inventions are advertised to industry.

APPENDIX B

OTHER PROVINCIAL GOVERNMENT INITIATIVES

Program or Service	Purpose	Eligibility	Form of Assistance
1) ALBERTA: Alberta Opportunity Company (Alberta Department of Industry & Tourism)	To promote the development of resources and diversification of the Alberta economy	Manufacturers and processors	Loans and loan guarantees, business management consulting. There are no forgivable loans under this program.
Alberta Agribusiness Loan Programs (Alberta Agriculture Development Cooperation)	To assist new agribusiness to become established and existing ones to expand	Agribusinesses that process primary products and/or provide a necessary service to farming enterprises	Direct loans to a maximum of $200,000. Guaranteed loans at preferential rates
Alberta Department of Business Development and Tourism Management Assistance Program	To improve the service, organization, and profit structure of small business by offering private sector management counselling	Small independent Alberta operators	Self-help assistance includes: analyzing, counselling and auditing results; improving management techniques; access to professionals. Participants are charged a nominal $25 fee.
2) BRITISH COLUMBIA: British Columbia Ministry of Industry and Small Business Development	To encourage industry to expand foreign trade and to investigate matters of economic importance	Companies resident in British Columbia	Cost sharing of trade shows, trade missions, market investigations, incoming buyers, feasibility studies.

Program or Service	Purpose	Eligibility	Form of Assistance
British Columbia Small Manufacturers Assistance Program (SMAP) (B.C. Ministry of Industry and Small Business Development)	To create jobs by assisting with the establishment, expansion or modernization of small manufacturing and processing businesses	Small manufacturing and processing businesses located in lower mainland and capital region of British Columbia	Subsidy in the form of interest-free forgivable loans
British Columbia Assistance to Small Enterprises Program (ASEP)	To create jobs by assisting with the establishment, expansion or modernization of small manufacturing and processing businesses	Small manufacturing and processing businesses located outside lower mainland and capital region of British Columbia. Also at least 51 percent of sales must originate at the wholesale level.	Subsidy in the form of interest-free forgivable loans
British Columbia Agricultural and Rural Development Subsidiary Agreement (ARDSA) (Federal Dept. of Regional Economic Expansion and B.C. Min. of Agriculture)	To develop the B.C. agricultural industry to secondary processing and value-added stages	Projects or plant locations must be located outside certain areas of British Columbia and must create at least three jobs.	Subsidy of eligible capital costs and new wages up to a maximum of $750,000 for new projects and $500,000 for modernization. The last date for project approval is July 31, 1982.
British Columbia Product Development Management Program (PDMP)	To assist manufacturing companies with management of product development activities	Taxable Canadian manufacturing corporations located in B.C.	Subsidy for preliminary assessment of the product development potential, plus additional assistance to carry out a product development project
British Columbia Development Corporation (BCDC) (Independent Board of Directors)	To encourage and assist the establishment, expansion and continued operation of industry in the province	All types of business enterprise, including agriculture and tourism	Loans and loan guarantees, equity participation, leasebacks

Program or Service	Purpose	Eligibility	Form of Assistance
3) MANITOBA:			
Manitoba Department of Industry and Commerce	To attract new business and assist with expansion of existing businesses by providing management, technical and long-term market market development assistance	All companies wishing to establish in the province or existing companies	Subsidy on a cost shared basis. There are a number of assistance programs available, each with more specific characteristics.
Communities Economic Development Fund (Manitoba Dept. of Industry & Commerce)	To provide funds for business development in rural Manitoba	Small, locally owned businesses engaged in manufacturing, tourism or services	Loans and loan guarantees in respect of land and buildings. For businesses in remote parts of the province
4) NEW BRUNSWICK:			
New Brunswick Department of Commerce and Development	To encourage modernization, expansion and establishment of small industry	Manufacturing, processing or related projects of companies whose sales do not exceed $1 million	Interest-free forgivable loans. Non-financial assistance is also available.
New Brunswick Financial Assistance to Small Industry	To assist in the growth of New Brunswick industry	All companies wishing to establish in the province or existing companies	Loans or loan guarantees. The corporation also administers three industrial parks. See also Provincial Holdings and Multiplex Corporation
New Brunswick Research and Productivity Council	To aid local companies and individuals in the manufacturing sector	All companies	Free technical information. Limited industrial engineering services are also available.

Program or Service	Purpose	Eligibility	Form of Assistance
5) NEWFOUNDLAND:			
Newfoundland Department of Rural Agriculture and Northern Development (Dept. of Rural Development)	To provide incentives to small business not eligible under other government assistance programs	Small businesses engaged in manufacturing, processing of resource development	(1) Grants of 50 percent of capital costs up to $30,000 in some cases (2) Interest-free loans (3) Management training Programs Assistance aimed mainly at rural-based industries
Department of Development	To provide marketing and product development assistance for exporters or import replacers	Newfoundland manufacturers and processors	Cost-sharing
Newfoundland and Labrador Development Corporation Limited	To assist the growth and development of Newfoundland industry	Newfoundland enterprises generating employment	Term loans for machinery and buildings. Equity participation in some cases. The Corporation does not provide loan guarantees.
6) NOVA SCOTIA:			
Nova Scotia Industrial Estates Limited	To assist in growth of Nova Scotian industry	Any secondary industry wishing to establish in Nova Scotia and existing industries	100 percent financing of land and buildings and 60 percent of equipment. Businesses with greater than $2 million in sales should apply to the SBDC.
Nova Scotia Small Business Development Corporation	To assist small businesses in Nova Scotia	Small businesses in Nova Scotia	Loans from $5,000 to $250,000 at fixed interest rates for the life of the loan. Replaces the small business divisions of the Resources Development Board and Industrial Estates Limited as of August 1981.

Program or Service	Purpose	Eligibility	Form of Assistance
Nova Scotia Department of Development	To assist Nova Scotia industry by way of various information and cost-sharing programs	Manufacturers, processors and selective services in Nova Scotia	Cost-sharing and information
Cape Breton Development Corporation (DEVCO)	To revitalize the coal industry and to establish a more diversified economy for the area	Existing and new companies wishing to establish in the Cape	Various financing assistance - wide mandate - no structured program
Nova Scotia Venture Corporations Act, 1980	To encourage investors to place equity or unsecured loans in small businesses	Registered venture corporations	Interest-free loans for up to 10 years. Must invest loan and own equity in eligible small businesses located in Nova Scotia
7) PRINCE EDWARD ISLAND:			
Prince Edward Island Industrial Enterprises Incorporated	To assist in the development of P.E.I. industries	Any resident manufacturing or processing industry or tourist attraction	(1) First mortgages (2) Source of information (3) Research and Management services Corporation may consider taking an equity position.
Prince Edward Island Lending Authority Act (Lending Authority Board, Dept. of Ind. and Commerce)	To provide working capital for small P.E.I. businesses	Any person, corporation or cooperative engaged in manufacturing, processing, farming, fishing or tourism	Loan guarantees and direct term loans. This act replaces the Fishermen's Loans Act, P.E.I. Industrial Corporation, Industrial Establishments Promotion, Tourist Accommodation and Young Farmers loan programs.

	Program or Service	Purpose	Eligibility	Form of Assistance
8)	QUEBEC:			
	Quebec Societe de Developpement Industriel (SDI) (Industrial Development Corporation (IDC)	To encourage development in Quebec	Secure, competent companies in manufacturing or processing	(1) Low interest rate loans (2) Guarantee of loans (3) Forgivable loans (4) Construction of plants for sale or rent (5) Equity investment (6) Leasebacks Replaces the Quebec Industrial Credit Bureau and extends its services
	Quebec Ministere de L'Industrie du Commerce et du Tourisme (Quebec Dept. of Ind., Commerce and Tourism)	To help innovative firms that are experiencing difficulty in obtaining risk capital	50 percent held by Quebec residents and legally incorporated for at least one year in Quebec	Related to the project and takes the form of a loan without interest for the first two years. 50 percent of the firm's revenues to originate from Quebec
	Program for the Modernization of the Textile, Knitting and Clothing Industry (Quebec Dept. of Industry and Tourism)	To increase competitive advantage	Firms operating in Quebec for at least one year	75 percent of expenditures to a maximum of $100,000, etc. The program has four sub-programs.
	Corporations for the Development of Quebec Business Firms (SODEQ)	To encourage investment of risk capital in small- and medium-size manufacturers	Individual and corporate Quebec resident tax-payers	Tax credits. Incentive available on original investment only

	Program or Service	Purpose	Eligibility	Form of Assistance
9)	SASKATCHEWAN:			
	Saskatchewan Economic Development Corporation	To supply financial assistance for establishment of expansion or industrial enterprises in Saskatchewan	Primarily for industrial enterprises or specialized agricultural operations	Mortgage loans and working capital loans, industrial sites and buildings research grants. Retail and service enterprises eligible
	Saskatchewan Department of Industry & Commerce	To create new business opportunities and revitalize existing enterprises, including tourism	All enterprises excluding farming	Loans or grants; consulting service; promoting marketing of goods and services. Loans administered by SEDCO
10)	NORTHWEST TERRITORIES:			
	Northwest Territories Department of Economics	To help finance any type of new business or expansion in N.W.T.	Any existing or prospective business in N.W.T.	Loans and guarantees. Similar in operation to FBDB
11)	YUKON:			
	Yukon Department of Tourism and Economic Development	To improve economic conditions of people of Yukon. To promote energy conservation in Yukon.	Individuals and companies in Yukon	Grant subsidies